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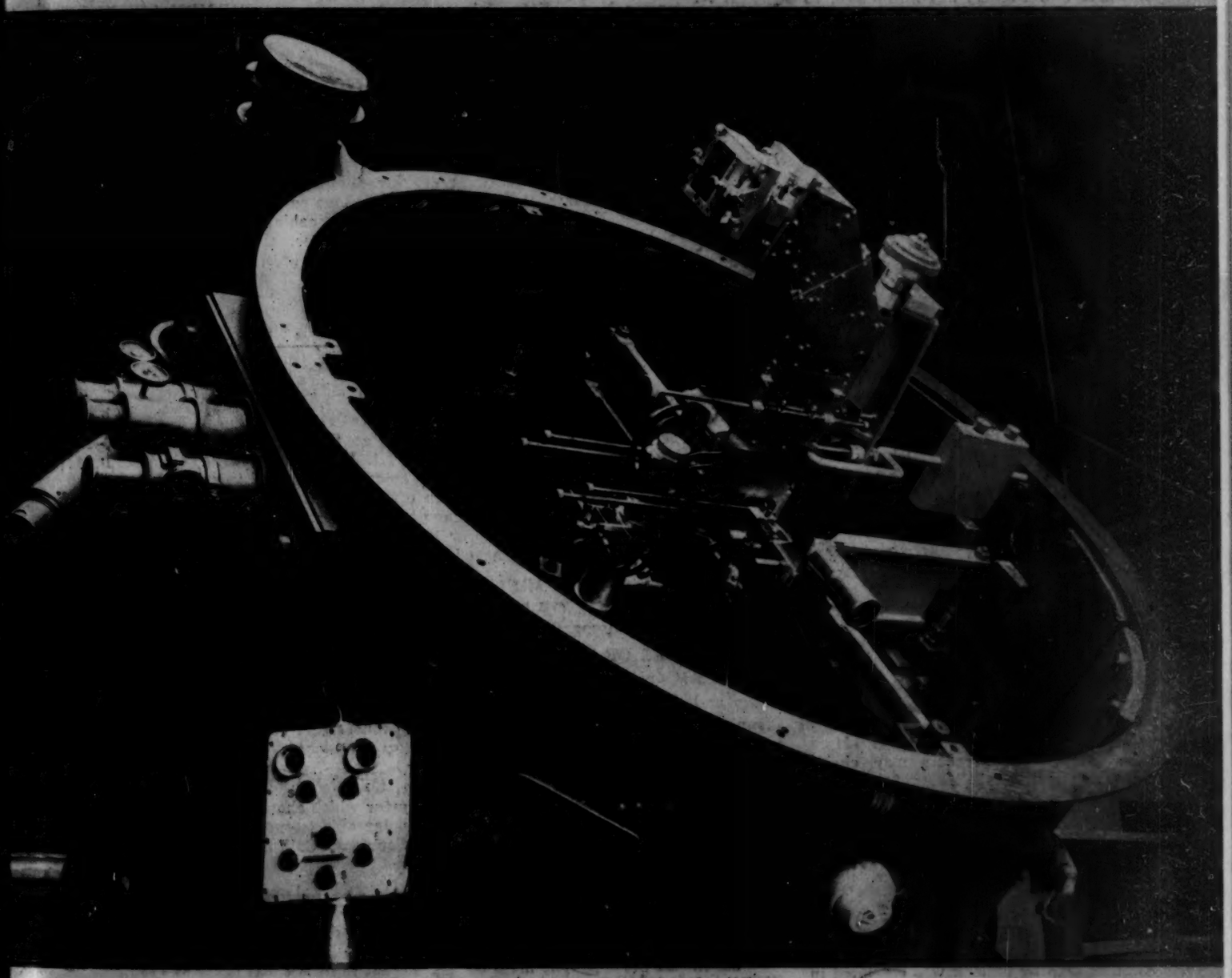

Nebular spectrograph

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Vol. VIII, No. 1
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In This Issue:

Inclinations of Spectrum Lines in Spirals

The "Application" of Telescopes: 1667 or 1668?

Congress in Switzerland — II

A New Atlas of the Heavens

Stars for November

LETTERS

Sir:

Cancer is a **crayfish**! It is not, and never has been, a lobster. And, believe it or not, it is only rarely a crab. [See **Sky and Telescope,** June, 1948, page 204.]

Since our word crayfish appears to be a corruption of the French "écrevisse," perhaps we should turn our attention first to sources written in that language. One of the best is Lalande, noted astronomer of the 18th century. The second edition of his authoritative **Astronomie** appeared in 1771, and comprises some 2,500 pages of delightful reading. He calls Cancer "l'Ecrevisse" (the crayfish) throughout. He specifically states (Art. 649) that Cancer has also been called Cammarus, which he says is Greek for écrevisse; also Astacus from the Greek, which he does not translate into French, but into Latin, as Cancer Marinus. This we might freely translate into English as **marine,** or **sea** crayfish.

Lalande's **Astronomie** was translated into Dutch in 1773, by Arnoldus Bastiaan Strabbe, with the co-operation of Cornelius Douwes. It was published in Amsterdam as **Astronomia, of Sterrekunde.** These Dutch authors call Cancer "de Kreest," which appears to mean both lobster and crayfish. But they go to the trouble of translating Lalande's Cancer Marinus into Dutch as Zeekreest. Now if Kreest means crayfish, Zeekreest must mean "sea crayfish," as has been noted in the preceding paragraph.

Looking up "sea crayfish" in a good dictionary, such as Webster's, we find "spiny lobster." Is Cancer a lobster after all? No, for a spiny lobster proves to be a kind of crayfish, genus **Palinurus,** not genus **Homarus,** which is the lobster. This "sea crayfish" lacks the chelae or large claws which distinguish the lobster.

Incidentally, let us pay a little attention to the term **Homarus.** With the sole exception of Dutch, all Teutonic languages have a cognate word for lobster. It is Hummer, which means lobster in German, Swedish, and Danish, and perhaps some other languages as well.

Let us return to the French for a moment, to note that Guillemin, writing in 1864 in **Le Ciel,** calls Cancer "l'Ecrevisse." From recent conversations with French navigators, I find it still so called. So, in French, Cancer is and always has been a crayfish.

How about modern German? Here is a source many readers may check. Schurig's **Himmels-Atlas** calls it Krebs (crayfish), not Krabbe (crab) or Hummer (lobster).

Most of the older star charts show Cancer as a crayfish, very much like a lobster, but with much smaller claws. Such, for example, is the way it is shown on a star chart in my possession, done by Peter Schenk and Gerard Valk and published in Amsterdam by Hondius in 1661. Another map by Schenk was reprinted in The SKY for January, 1939, where Schenk's name is erroneously given as Scheln, and readers who have this copy at hand may compare the delineation of Cancer therein with the Dürer maps published in the September, 1947, issue of **Sky and Telescope.** The resemblance is striking.

English-speaking authors who refer to Cancer as a lobster are under a misapprehension which appears to be widespread. If you order a lobster in a restaurant in most of the United States, you will be served a sea crayfish, sometimes called a Gulf lobster, or New Orleans lobster. Any New Englander will know the difference, not only by the absence of the large claws, but even by the taste. The meat is not so sweet as the genuine lobster, genus **Homarus.**

Even in Europe, the traveler will seldom, if ever, meet a genuine lobster. Menus in Lisbon, Madrid, and Paris often list lagosta, langosta, or langouste, respectively, but it is always the crayfish that is served. In French, the genuine lobster is called homard, reflecting the Teutonic Hummer, but I have never seen "homard" on a Parisian menu.

Incidentally, one last word on the term "crayfish." I have employed this word throughout, because it is closer to the French "écrevisse" than the more American term "crawfish," which means exactly the same thing. There is no distinction between the two names.

So, while Cancer may be a crawfish, a crayfish, and sometimes a crab, it's definitely not a lobster.

SIDNEY SCHEUER
675 West End Avenue
New York, N. Y.

Sir:

A **Sky and Telescope** accessory has been "invented" by me, the patent rights to which I gladly relinquish. I have bought an oak frame with narrow molding, of just the size to hold a copy of the magazine. Transparent film is used instead of glass. Two small brass bars in back, one movable, enable me to hold and change the magazine, thus displaying different last-page pictures, one at a time.

L. S. COPELAND
1124 State St.
Santa Barbara, Calif.

Sky and TELESCOPE

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VOL. VIII, NO. 1
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NOVEMBER, 1948

CONTENTS

COVER: The nebular spectrograph mounted at the prime focus of the 36-inch Crossley reflector, Lick Observatory, Mt. Hamilton, Calif. This instrument is provided with auxiliary guiding eyepieces and optical systems that make it possible to photograph the spectra of very faint and even invisible objects, in the range from 14th to 18th magnitude. Exposures average five to six hours, and occasionally extend to 10 or 12 hours. The spectra are only a few millimeters long and usually show less than six measurable lines. (See page 3.)

INCLINATIONS OF SPECTRUM LINES IN SPIRALS — N. U. Mayall 3
THE "APPLICATION" OF TELESCOPES: 1667 OR 1668? — J. W. Olmsted 7
CONGRESS IN SWITZERLAND — II 8
A NEW ATLAS OF THE HEAVENS — Zdenek Kopal 13

Amateur Astronomers 17
Books and the Sky 18
Gleanings for ATM's 20
In Focus 11
Letters 2
News Notes 6
Observer's Page 26
Planetarium Notes 24
Stars for November 25
Terminology Talks 12

BACK COVER: A drawing by Russell W. Porter which shows the horseshoe bearing and oil-pad mechanism of the north polar axis support of the 200-inch telescope, Palomar Observatory, Calif. Courtesy, California Institute of Technology. (See In Focus.)

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Inclinations of Spectrum Lines in Spirals

By N. U. Mayall, *Lick Observatory*

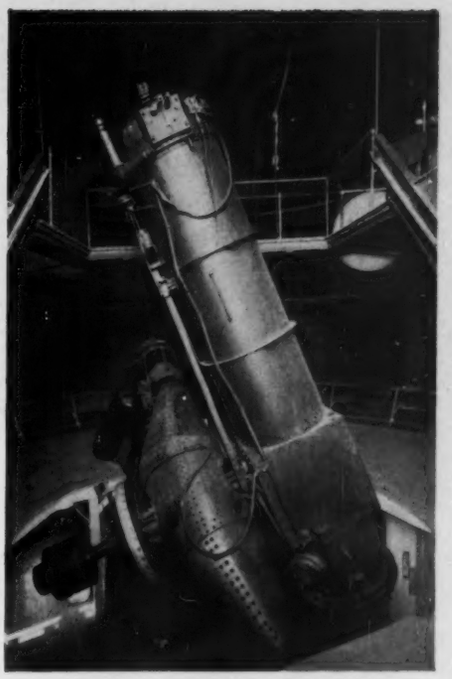
THIRTY-FIVE years ago V. M. Slipher placed the slit of a spectrograph on a spiral nebula and obtained a spectrogram that showed inclined lines. From this result he concluded that the spiral was rotating about an axis — that on one side of its center the material of the galaxy was approaching us relative to the center and on the other side receding. His pioneer observation and its interpretation not only antedated by more than 10 years the discovery of the rotation of our own Milky Way galaxy, but it opened a new field of investigation: the study of dynamics in the largest known stellar systems. The field, however, has proven difficult to cultivate, and even now our factual knowledge in it is in the broad exploratory stage.

At the outset it should be stated that the interpretation of spectrum-line inclinations as rotations is fraught with many difficulties. When the slit of a spectrograph is placed on a spiral the resulting spectrogram represents a large-scale integration over many motions and radiations throughout a large portion of the system. This condition is especially true for the edge-on spirals and the large amorphous nuclear regions of early- and intermediate-type spirals. To be reasonably certain of what motion corresponds to what point in a spiral, it is desirable to observe individual objects, and to know where they are located with respect to the fundamental plane. Unfortunately, with present techniques, this ideal approach can be made in only a few of the nearest spirals; in fact, it has been done only for the two nearest of them, M31 and M33. Observations of their brighter emission patches, which probably correspond to the larger galactic nebulosities, indicate that, on the grand scale, the main bodies of these spirals rotate nearly as solid bodies, while their outer parts show a planetary or Keplerian type of motion (slowest farthest from the center).

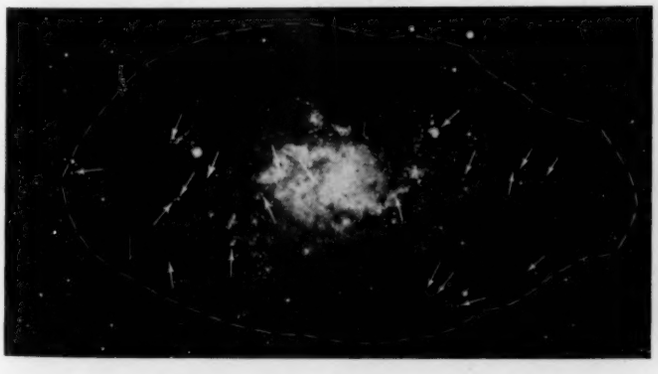
For M31 and several early-type nebulae observed at Mount Wilson, initially by F. G. Pease and later more extensively by M. L. Humason, it was found that the spectrum lines are conspicuously inclined, and sensibly straight, in the vicinity of the nuclei. Since in these cases the light on the slit came from unresolved, absorption-line nebulosity on the major axis, the interpretation of the observations in terms of simple, solid-body rotation requires some justification. This seems to have been provided in a theoretical paper by E. Holmberg.

In 1939, Holmberg investigated the ratio between observed radial velocity and circular orbital velocity as a function of nuclear distance for several assumed distributions of mass, light, and absorption within spherical nuclei. The inclusion of a factor for absorption probably is not necessary, since there is increasing evidence that most of the absorbing material in a spiral is confined to a quite thin, patchy stratum in the principal plane. Nevertheless, Holmberg found, in the general case for Gaussian distributions of mass, light, and absorption, that the ratio varies almost linearly with nuclear distance. Moreover, the precise form of the distribution functions does not seriously affect the linearity of the relation, provided that there is appreciable central concentration of mass and light within the nucleus. In short, the interpretation of straight inclined lines in nuclear regions as an indication of solid-body rotation seems to be acceptable as a working hypothesis. On this basis, the nuclear regions of M31 and of several early-type nebulae appear to be rotating faster than their respective main bodies.

The foregoing briefly summarizes the detailed results previously published for four spirals and one elliptical galaxy. In a first crude attempt to expand this meager but hard-won body of data, the pres-

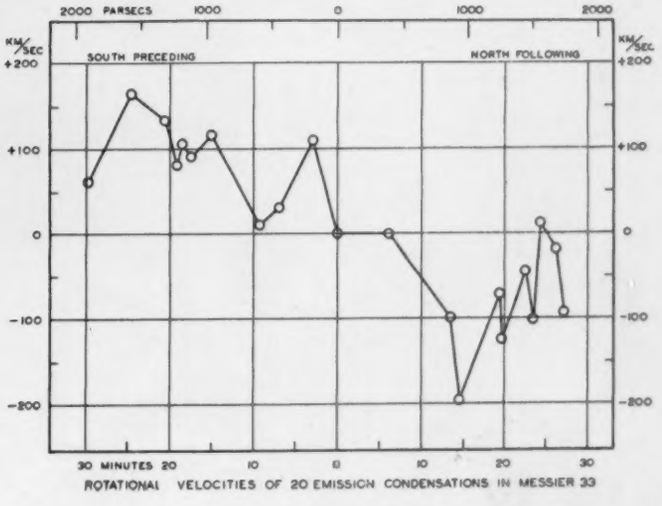


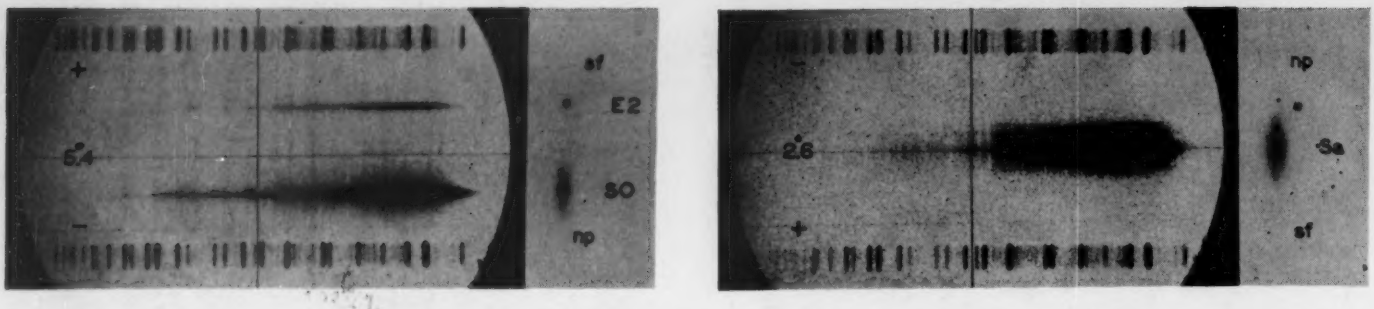
The 36-inch Crossley reflector of the Lick Observatory. It was with this telescope that much pioneering work on nebulae was done by J. E. Keeler, H. D. Curtis, and W. H. Wright. The current nebular program is concerned primarily with the measurement of red shifts and rotational motions of galaxies.



The arrows on this photograph of M33 indicate the emission patches for which rotational velocities derived from the observed Doppler motions are plotted in the chart at the right. Positive motion is away from the observer. The horizontal scales give (upper) linear and (lower) angular distance from the center of the spiral. Note that the rotational speed increases with distance from the center throughout the main body, and then decreases in the outer parts.

THE ROTATION OF MESSIER 33





Typical spectra which show the inclinations in the lines by which the rotation of a galaxy is determined. At the left is NGC 1332, which has an estimated distance of 2½ million parsecs and a period of about six million years for the rotation of its nuclear region. It has a fainter companion elliptical galaxy. NGC 5866, at the right, is at a distance of 1½ million parsecs, and its main body is found to rotate in about 6½ million years.

ent preliminary discussion, based on 30 low-dispersion spectra that show inclined lines, has been prepared.

All exposures were made with the nebular spectrograph (see the front cover) of the 36-inch Crossley reflector of Lick Observatory. The linear dispersion varies from 220 angstroms per millimeter at wave length 3727 to 430 at the hydrogen-gamma line. The material is heterogeneous, dates back in some cases to 1935, and was taken mainly for radial velocity determinations, so that it is by no means the best that could be obtained in a well-planned study of nebular rotations. At first, when emulsions were slower, only the nuclear regions were recorded. After the war, when the faster and finer grained Eastman IIa-O emulsion became available, it was possible to obtain spectra of most of the main bodies of a number of spirals. Wherever possible, the slit was placed along the major axis of each system, and to check that the line inclination originated in the spiral, rather than from instrumental causes, several duplicate exposures were made with the slit rotated 180 degrees between exposures.

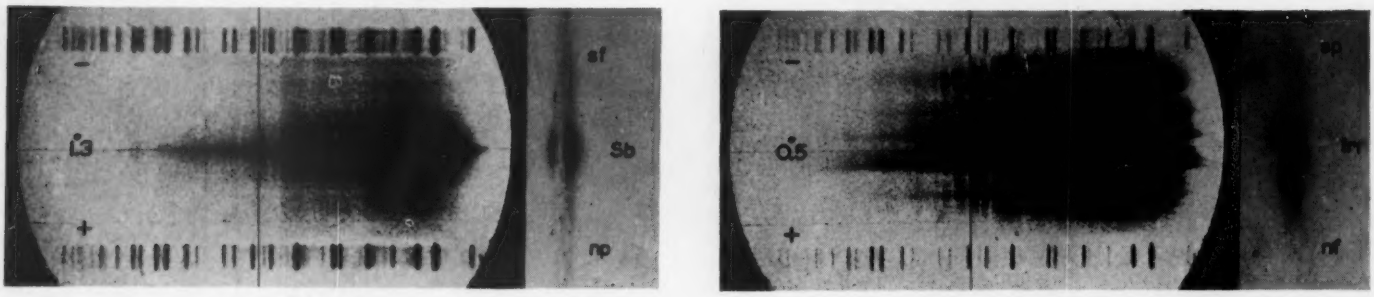
In analyzing the spectra, plates of six late-type spirals oriented nearly edge-on were measured in the usual manner by setting a micrometer wire on the spectrum lines at a number of different points along each line. In all six spirals an essentially straight-line relation was obtained between nuclear distance and velocity. This result suggested that the laborious, numerous micrometer wire settings along each line might be replaced by measurement of the inclination of each spectrum line as a whole, by rotation of the spectrogram.

This procedure proved to be rapid and without systematic differences from the usual method, when a small Gaertner measuring engine, with a plate-carrying table that can be rotated and read to 1/100 degree, was adapted to the purpose. Settings on comparison lines usually repeated to a few hundredths of a degree, while the agreement among those on nebular lines depended strongly upon the lengths and visibility of the lines. Under the most favorable circumstances, corresponding to a maximum slit length of six minutes of arc, or 2.2 millimeters width of spectrum, and for eight lines of good visibility, the probable error of a mean inclination was 0°.03 to 0°.05 (plus or minus). For the narrowest measurable spectra 0.11 millimeters wide, and for only several lines of poor visibility, probable errors up to 0°.5 were obtained. In the present material, it appeared that inclinations of the order of 0°.1 were the smallest that could be detected in spectra of average characteristics. As a rule, the line at 3727 angstroms, and the H and K lines of ionized calcium were best suited for measurement, but occasionally some ultraviolet blends, hydrogen-delta, the G-band, and hydrogen-gamma were included with lower weight.

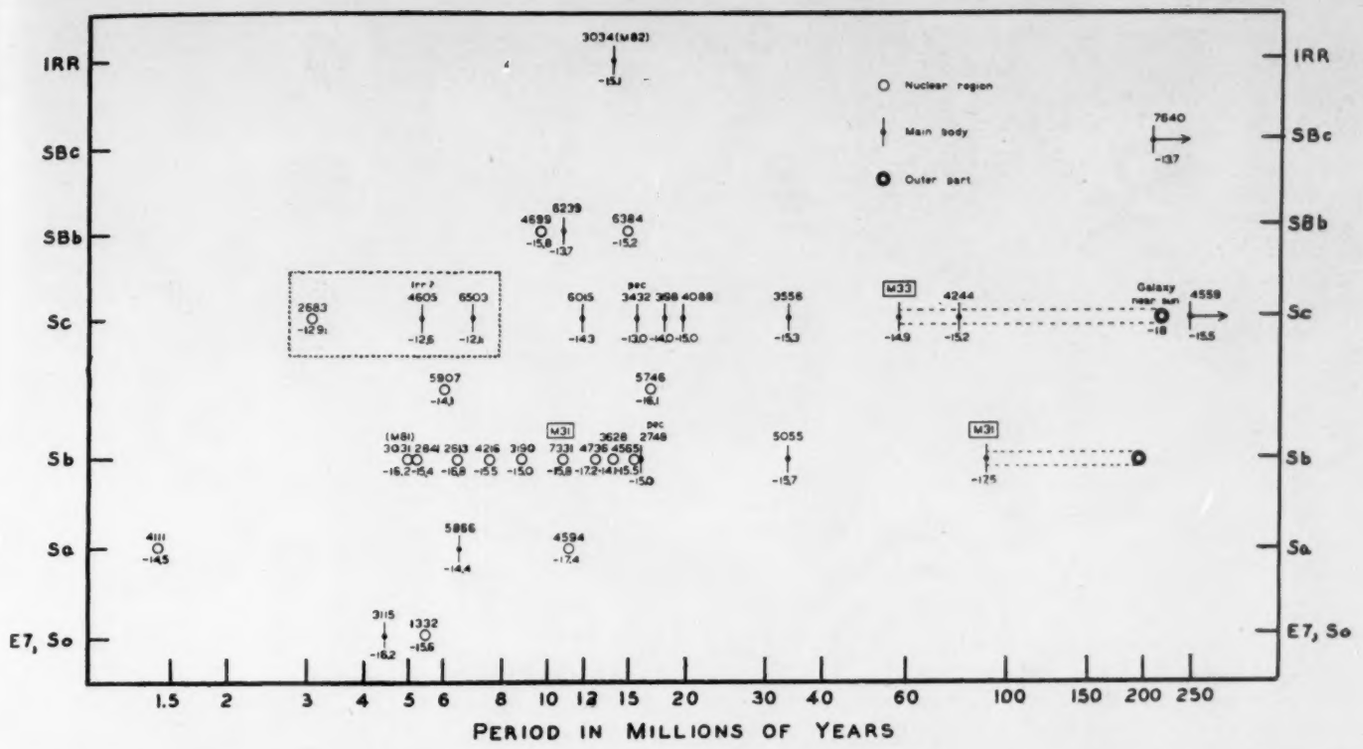
It should also be emphasized that the spectra, in addition to being of low dispersion, are of quite small scale in the direction perpendicular to dispersion. In fact, with a reduction factor of 4.3 from slit to plate, the scale along a spectrum line is 168 seconds of arc per millimeter, which corresponds to an equivalent telescope focal length of only 48 inches. Small irregularities in shifts, a slight general curvature of lines, or a greater line inclination in the immediate vicinity of the nuclei could easily escape detection on spectrograms of such small scale.

Some idea of the problems of measurement and interpretation involved in deducing results from so little physical evidence may be gained from the accompanying illustrations. The spectra as reproduced here were photographed through the eyepiece of the measuring engine, and the pictures therefore show how the spectra appeared during measurement. The only liberty taken in preparing the pictures was to enhance with a sharp pencil the very fine vertical crosswire, which otherwise would be almost impossible to see. To the right of each spectrum is a direct photograph of the nebula, enlarged to the same scale as the direction perpendicular to dispersion.

The tilt in the early-type (So) system NGC 1332, 5°.4 at the H and K lines, is the largest measured. The spectrum is also the narrowest, so the inclination is uncertain by at least 0°.5. NGC 5866 is also an early-type galaxy; inclination of lines, 2°.6.



NGC 4565, shown at the left, is an edgewise spiral of intermediate type. The nuclear region has inclined lines indicating a period of revolution of about 16 million years for its distance of 1.7 million parsecs (5½ million light-years). At the right is the irregular system, NGC 3034. All spectra were photographed at the Lick Observatory, and represent enlargements of 13 times from the original negatives.



This diagram shows the rotation periods of the galaxies arranged acording to nebular type, with the absolute magnitude for each object. The rotation periods of nucleus, main body, and outer regions are designated by different symbols. For M31 and M33, the range of periods in their outer parts is indicated by dashed lines; that in our galaxy for the solar neighborhood is also included. The arrows attached to the points for NGC 7640 and 4559 mean that lines in the spectra of these two spirals showed no measurable inclination, and that their periods of rotation are longer than plotted.

NGC 4565, also pictured here, is considered a typical edge-on spiral with a prominent dark lane silhouetted against the nuclear region. Although the exposure was five hours on IIa-O emulsion, the spectrum of only the brighter nuclear region is recorded in measurable strength. A longer exposure could be used, but the spectrum of the outer parts of the spiral would be confused with night sky radiations. The inclination for NGC 4565 is 1°.3.

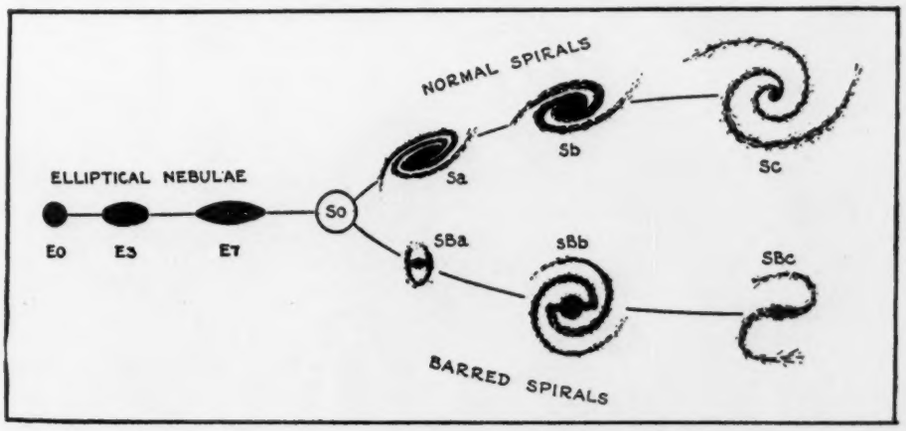
The lines in the spectrum of NGC 3034, better known as M82, the irregular companion of M81, are measurably inclined. This is perhaps the best example of an early-type absorption spectrum infrequently found in the nuclei of spirals. In this case, a spectral class of about *A7* is indicated, and it is noteworthy that the same type of spectrum apparently prevails throughout most of the system, with occasional regions where emission at 3727 angstroms is conspicuous.

The measured line inclinations were finally used to compute periods of rotation for these 30-odd systems. To do this the distance of each object must be estimated, and this was done, in most cases, from red shifts in their spectra corrected for the effects of galactic rotation. Eight of these spirals are in the Ursa Major group of galaxies, and one in the Virgo cluster, so that their distances are reliable. The computed periods were corrected, where necessary, for the tilt of the principal plane to the line of sight. The absolute magnitude for each spiral was also computed.

The results have been collected in the accompanying chart, where the periods of rotation are shown according to type of galaxy. The periods are in millions of years, and plotted on a logarithmic scale because of the large dispersion found for the later-type spirals. Periods for the nuclear regions and the main bodies are differentiated, and for comparison those of the outermost parts of M31, M33, and the solar neighborhood of the Milky Way galaxy are included.

The chart does not suggest any very striking generalizations. For example, there is no correlation between absolute magnitude and period. On the other hand, if the three objects in the dotted rectangle be disregarded because of uncertain distances or a possible reclassification, there is some suggestion of a general increase in period of the main bodies with advancing nebular type. However, there are so few early types, the intermediate types are represented almost entirely by nuclear regions, and the dispersion in period is so large among the late types, that averages according to type would have little significance. In view of these obvious deficiencies in the data, it would seem best to defer conclusions

(Continued on page 17)



The sequence of types of extragalactic nebulae, from the book, "Realm of the Nebulae," by Edwin P. Hubble. A few galaxies of mixed types are found between the two sequences of normal and barred spirals, while S0 is a transition stage at which structure, not always spiral, can just be detected.

NEWS NOTES

By Dorrit Hoffleit

OBSERVATORY IN THE CONGO

A new nine-million-dollar institute for general scientific research, l'Institut pour la Recherche Scientifique en Afrique Centrale (or briefly, the IRSAC), is being established in the Belgian Congo. Its international character is indicated by the appointment of a British biologist, Dr. E. B. Worthington, a French botanist, Professor A. Chevalier, and an American astronomer, Dr. Harlow Shapley, to its board of administration. Director of the new scientific foundation, which will have an annual subsidy of half a million dollars, is Dr. Louis van den Berghe, professor of tropical medicine in Antwerp and visiting professor of tropical medicine at Tulane University.

Several research stations will be erected in the Belgian Congo during the next two years, including seismological and ionospheric observatories. Of special interest is the fact that a search is already being made for a most suitable site for a high-altitude astronomical observatory, which would thus have a strategic location within a few degrees of the equator.

DEBRIS OF A PLANET?

For nearly a century scientists have speculated as to whether or not the mean composition of meteorites is about the same as that of the earth. Within the past few years, Dr. Harrison Brown and Claire Patterson, of the Institute for Nuclear Studies, University of Chicago, have been analyzing meteorites quantitatively in much greater detail than had ever been done previously. A paper in the March *Journal of Geology* indicates strongly that meteorites had their origin in a planet similar to the earth in general physiochemical characteristics.

Assuming that the observed distributions of elements in meteorites represent equilibrium conditions, the Chicago scientists conclude that such equilibrium must have been established at temperatures of the order of 3,000° centigrade and at pressures of 10^5 to 10^6 atmospheres. Moreover, these conditions must have varied from meteorite to meteorite in such a manner that the greater the metal-phase content, the greater the temperature and/or pressure. No other theory yet propounded fits all of the observations as well as the one that the meteorites are fragments of a planetary body whose physiochemical properties, like those of the earth, varied according to the depth of the material below the surface.

These conclusions are extended by independent investigations by Dr. Carl A. Bauer, University of Michigan, who some time ago found that the helium content of meteorites depended on cosmic radiation as well as on spontaneous radioactivity. Dr. Bauer reports in the *Physical Review* that the parent planet from which all meteorites originated was born less than 60 million years ago. This value is an upper limit: all of the uranium and thorium contents of the meteorites he studied are sufficient to have produced all of their respective helium content in this period. The parent planet was presumably smaller than the earth and moved in the asteroidal zone between Mars and Jupiter.

HEAVY COSMIC RAYS

High-altitude balloons carrying cloud chamber and photographic recording equipment for physicists of the universities of Minnesota and Rochester (under project Skyhook of the Office of Naval Research) have recorded cosmic ray particles of considerable atomic weight, some as heavy as hafnium, element No. 72, atomic weight 180. The tracks of these particles at a 20-mile altitude are many times denser and heavier than those obtained from fragments in nuclear explosions, indicating extremely high energies. Dr. W. F. G. Swann, of the Bartol Research Foundation, suggests that small electric-field potentials in the universe operating over considerable periods may give stray heavy atoms the tremendous velocities which are apparently observed in these experiments.

SUNDIALS AND THE ORIGIN OF CONIC SECTIONS

The theory of conic sections familiar to all mathematics students dates from Pergaeus Apollonius about 220 B.C. "Very little, however, is known about the origin of conic sections as such," states Professor Otto Neugebauer, of Brown University. Of special interest to sundial enthusiasts will be his brief article, "The Astronomical Origin of the Theory of Conic Sections," in a recent issue of the *Proceedings* of the American Philosophical Society. He describes the theory accredited to Menaechmus, about 350 B.C. Suppose we have a plane perpendicular to one directrix of a right circular cone. As the directrix generates the cone, it traces on the plane a conic section. The complete array of conic sections is found by varying the vertex angle of the right circular cone. If the vertex angle is large, the conic is a hyperbola.

Dr. Neugebauer sets out to show that "a very simple type of sundial satisfies all requirements for Menaechmus' definition of conic sections." Thus, if a unit length gnomon is adjusted in such a way that it always points toward the sun when it culminates, and if the plane of the sundial is perpendicular to the gnomon, the length of the shadow tells the time. The Brown University scientist states his confidence that this explanation gives the real motivation for the early Greek theory of conic sections, although he does not know of the actual existence of a sundial of this type. In nearly all sundials, the shadow plane is either horizontal or vertical.

ICE AGES FROM A NEBULA?

The passage of the sun and the earth through a very tenuous nebula was proposed as a cause of the ice ages by Dr. Donald H. Menzel, Harvard College Observatory, at the recent centennial meeting of the American Association for the Advancement of Science. The possibility that an ice age might recur in the future were similar astronomical events to take place was also mentioned.

Within the past million years the earth has experienced four separate periods of glaciation, probably affecting all continents and both hemispheres. None of the various previous proposals to explain the ice ages appears to be adequate. The suggestion that the sun may have varied its energy output sufficiently does not find geological or astronomical confirmation, although the possibility of long-range solar variation has not been disproved.

Dr. Menzel called attention to the existence in space of many extended dark nebulae, clouds of dust that obscure the light of the stars behind or inside them. In the course of geological time, our sun has probably passed through many such nebulae.

A dark nebula is so tenuous that such material between the earth and the sun would exert a negligible effect on the heat and light reaching our planet. But an extensive cloud, even if partially transparent, could scatter an appreciable amount of radiation from the sun back to the earth—increasing the total energy received by as much as five, 10, or even 15 per cent, Dr. Menzel suggested. The additional heating of the earth would help to start and maintain the high evaporation of water from the oceans considered as essential to the mechanics of the ice ages. Meteorologists today are generally agreed that a cold age is not necessarily an ice age, so that glaciation may have been extensive at periods warmer than we have at present.

If the sun has been traversing a dark nebula, from which it emerged only some 50,000 years ago, the outer fringes of the nebula should be only about one parsec away in the direction of Columba. The nebula might well be so thin that its effect on the light of more distant stars is negligible. Variations in its density as the sun passed through it, or the passage through more than one nebula, could account for the ice-free interglacial periods.

The "Application" of Telescopes: 1667 or 1668?

By J. W. Olmsted, *University of California*

THE APPLICATION of telescopes to instruments with graduated arcs for measuring celestial angles marked one of the capital advances in the history of modern astronomy. The use of the telescope as a device for accurate pointing was a prior condition to the establishment of astronomy as a science based on precise celestial measurements. Observations like those of Tycho Brahe, which were made by looking with the naked eye through open sights, enabled Kepler to discover his famous laws of planetary motion. They were not, however, sufficiently refined and dependable for the further progress of positional astronomy. For this it was first necessary to convert the telescope from an instrument whose usefulness was confined to exploration and description, as was still the case for nearly a quarter of a century after Galileo (died 1642), into an instrument of precision as well.

The history of the application of telescopes to astronomical instruments has for two centuries remained veiled in obscurity. Essentially all that is known is that Abbé Jean Picard (1620-1682) and Adrien Auzout (1622-1691) had something to do with it, and that it took place in Paris in the latter part of 1667. Most frequently the date is said to be not later than October 2, 1667, "date of the first observation [with telescopically equipped instruments] of which any record has come down to us," according to the influential statement of astronomical historian J. B. J. Delambre. Such is the meager information to be obtained from standard histories of astronomy or of astronomical instruments. Actually, in addition to the correction of the rather glaring error in the date traditionally assigned to the application, there is a good deal to be learned as to *how* it was accomplished, and *why* it came about just when and where it did.

The first step in the right direction to have a permanent effect was taken in 1665-1666. In the course of those years a simple and reliable filar micrometer with which *small* celestial angles could be measured to within a few seconds or less was developed in Paris. It was largely the work of Auzout, a somewhat obscure astronomer and scientist. At about this time a group of able and ingenious observers, including men like Auzout, Picard, Roberval, and Buot, was becoming increasingly active. The arrival of the Dutch scientist Christian Huygens (1629-1695) in their midst in the spring of 1666, preluding as it did the formal organization at the end of the year of the Académie Royale des Sciences, had a catalytic effect.

Early in July, 1666, members of the group successfully employed one of Huygens' improved and highly accurate pendulum clocks for the observation of a solar eclipse. An ambitious program for the renovation and improvement of astronomy, including such tasks as the preparation of new and refined astronomical tables, an accurate measurement of the earth, and an astronomical expedition to Madagascar, was also beginning to take form. With small angles being consistently measured to within a few seconds by means of Auzout's micrometer, a comparably accurate and dependable method of determining such large celestial angles as azimuths and altitudes was imperative. Even the improved open sights currently in use were incapable of the precision and refinement essential to the tasks in view.

Sometime late in 1666 or early in 1667 experiments with lenses were begun. The initiative appears to have come from Auzout and Picard. The immediate object seems to have been to improve the "seeing" qualities of open sights by using them in combination with lenses. Nevertheless, by the late summer or early autumn of 1667 a clearly distinguishable preliminary stage in the creation of a revolutionary new optical or "telescopic" type of sight had been reached. Lenses (not telescopes, as heretofore asserted in consequence of the misinterpretation of a key phrase) were successfully "applied to the sights" of certain old sextants and quadrants whose radii varied from around six to more than nine feet. Huygens described the arrangement as "like a telescope without a tube." To contemporaries it thus suggested a miniature version of the great tubeless telescopes then in use (see *Sky and Telescope,* VII, 115, March, 1948). Crosshairs, however, had as yet not been mounted in the focal plane between the convex ocular and the convex objective, although a single hair for taking altitudes is said by Huygens to have been in use.

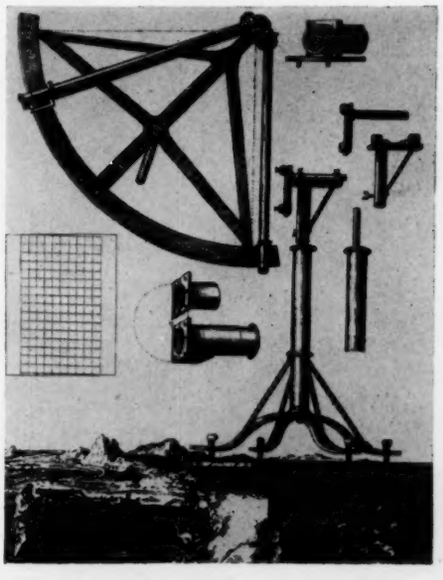
Open sights on the alidade of an instrument used by Tycho Brahe.

Efforts to improve this initial tubeless arrangement of lenses were actively continued, particularly by Picard. (Auzout, unfortunately, was soon to depart for Italy into virtual exile.) In consequence, by the autumn of 1668 the decisive second stage in the development of telescopic sights had been reached — *a full year later than the date traditionally assigned to this event.* Not later than October, 1668, a completed telescope, including the enclosing tube and the crosshairs which were essential to collimation and accurate pointing, was incorporated by Picard as an integral part of a specially built little quadrant whose radius was only 28 inches.

In one sense, however, the application of telescopes was not fully completed even by 1668. Neither the accuracy nor the dependability of the new sights could be taken for granted. That they could measure large angles precisely had to be demonstrated. Only at the end of March, 1669, was Picard fully convinced of their exceptional merit. The new sights, he promptly informed his colleagues of the academy, had proved consistently accurate to the nearest five or six seconds during a period of use of more than five months.

The opportunity to utilize telescopically equipped instruments in a systematic way speedily followed. The proposed measurement of the earth, which seems to have been held up mainly through the limitations of open sights, was pushed rapidly ahead during the late summer of 1669. The operations for the measurement of an arc of a meridian

(Continued on page 19)



Telescopic sights on Picard's 38-inch quadrant, one of the instruments used to measure an arc of the circumference of the earth.

The Dent Blanche, seventh highest peak in the Alps (14,318 feet), dominates this scene looking northwest from the lower slopes of the Matterhorn. The Zmutt glacier is in the lower foreground. All photographs in this article are by the editor.

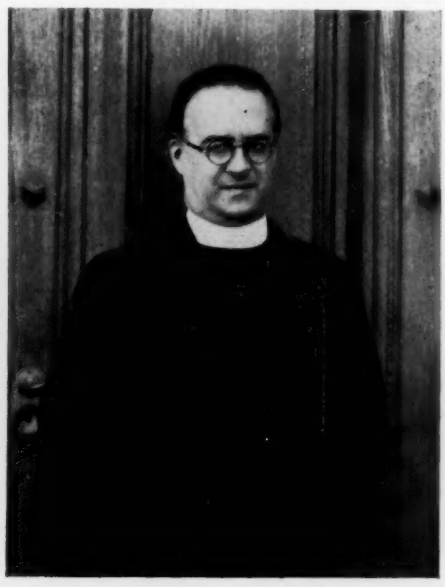
CONGRESS IN SWITZERLAND

PART II

RESOLUTIONS were the order of the day on August 18th, when the closing session of the general assembly of the International Astronomical Union was held in Zurich. They were proposed by the executive committee and by the various commissions, many of them directly resulting from discussions in the preceding meetings of the commissions. The resolutions, of which nearly a hundred were adopted by the general assembly, concerned the granting of funds for research and the publication of astronomical data, current shortages and needs in observation and research, questions of policy and procedure. Some resolutions of more general interest were:

The *executive committee* proposed, "As the advancement of astronomy is hindered when the results of observations and researches are published in a language that is not generally understood by astronomers, the Union recommends that publications in any such language should be accompanied by an abstract in one of the widely read languages. The Union notes with satisfaction that this procedure is already widely followed but, as there are many exceptions, it hopes that the procedure will become general."

Commission 4, *Ephemerides,* recommended that the designation "Universal time" *(Temps universal, Weltzeit)* be used exclusively by astronomers to indicate mean solar time, reckoned from



Seen at Zurich were, left to right, Dr. A. Hunter, Greenwich Observatory; Dr. G. Abetti, Arcetri, Italy; Canon G. Lemaitre, Belgium.

(Left) Dr. R. O. Redman, director of the observatories at Cambridge, England. (Center) Dr. Julie M. Vinter Hansen, director of the international telegraphic bureau at Copenhagen Observatory, Denmark. (Right) Dr. Eric M. Lindsay, Armagh Observatory, North Ireland.

midnight of the Greenwich meridian.

Commission 5, *Analysis of Results and Bibliography,* which had requested at Stockholm in 1938 that the observatory at Lund establish a card index of astronomers and observatories, now considers that it would be most useful to publish as soon as possible a list of observatories and astronomers, such as was previously edited by the national observatory in Belgium.

The same commission also reported that a committee has been established by the Royal Society of London to insure publication of the letters of Sir Isaac Newton, as had already been proposed at Stockholm.

Commission 12, *Solar Radiation,* recommended that financial aid be granted to the publication of a revised table of the solar spectrum, which would be of great importance to astronomers engaged in solar research and in the investigation of stellar spectra. In order to reduce the delay in publication, Commission 12 suggested that the revised table be limited to the still unpublished spectral range from 3063 to 6600 angstroms.

Commission 19, *Variation of Latitude,* pointed out "the great utility of establishing photographic zenith tubes in various places throughout the world, not only for improving the knowledge of the polar motion, but also for providing much needed data in regard to the proper motions of the stars in declination, and for providing material which is useful in the determination of the constants of the solar system. For the determination of the polar motion, several stations in about the same latitude are desirable, while for the determination of proper motion, stations located at various latitudes are required."

Commission 20, *Minor Planets, Comets, and Satellites,* recommended that the periodic comet Pons-Coggia-Winnecke-Forbes should in the future be called Crommelin's comet. It was also proposed by this commission that permanent numbers shall, as a rule, be assigned to new minor planets after they have been observed in two oppositions and a satisfactory orbit obtained. In the case of a planet that approaches the earth within the orbit of Mars, a permanent number may be assigned after a single opposition provided the planet has been well observed and a satisfactory orbit has been obtained.

Commission 22, *Meteors, Zodiacal Light, and Analogous Problems,* recommended that "simultaneous observations of meteors by electronic (radar) and visual or photographic means be extended because the commission is convinced that the continuation and extension of electronic observations is now essential to the proper advance of meteoric astronomy and of researches related to it."

Commission 27, *Variable Stars,* pro-

(Left) Many astronomers took part in an excursion to Lucerne, one of Switzerland's famous cities, where this picture was taken.

(Right) Dr. and Mrs. R. J. Trumpler, of Lick Observatory, both of Swiss birth, photographed during the Lake Zurich excursion.

Looking from the summit of the Moench, 12th highest Alp (13,457 feet) toward the Finsteraarhorn. Several astronomers climbed the Moench (Dr. Chalonge making his 13th ascent), as did the editor's family. Tony, leading on the rope, waits to let a party descend the ridge safely. The last two miles back to the Jungfraujoch were skied on perfect snow.

Enthusiastic "promenaders," as distinguished in Switzerland from mountaineers, at the Belvidere Hotel, 10,820 feet high on a ridge of the Matterhorn. They watch a party of three descending from the summit, infinitesimal specks against the rock and snow. Note that the Zeiss refractor at the left has just been used to observe a group coming up to the hotel.

posed financial support for the preparation of charts of variable stars in the Southern Hemisphere for the benefit of amateur astronomers. The commission also stressed the value of visual observations of certain classes of variable stars.

Commission 31, *Time,* proposed on behalf of geodesists, who wish to determine at once the rates of their timepieces, that observatories which direct the broadcasting of time signals take steps to insure that, from one day to another, the corrections of the signals do not change too much.

Spare time was at a premium during the congress. Upon registering, each delegate received a booklet of tickets entitling him to attend or go on or take part in a variety of extracurricular activities. A special series of excursions, luncheons, and teas was also arranged for visiting women non-astronomers.

On the first day, luncheon for all was served at the Kaufleuten Restaurant, by invitation of the Swiss National Committee on Astronomy. The next day there was an excursion on Lake Zurich; the party traveled to see the castle and Polish Museum at Rapperswil, where a banquet was held at the Schwanen Hotel. On Friday evening, many of the visitors enjoyed particularly an organ recital in the Grossmünster, and on Monday evening there was a serenade in the cloister at the same place.

Saturday, August 14th, in the afternoon, a special train took astronomers and guests to the top of the nearby Uto-Kulm, where tea was served, and afterwards one could return to Zurich by train or on foot (Swiss style). Sunday's three all-day excursions gave one the choice of the Klausenpass or the Sustenpass (by busses with open tops) or of a train-ship-train journey via Lucerne and Vitznau to the top of the Rigi.

On Monday afternoon, time permitted inspection either of the labora-

Left to right: Dr. A. Danjon, director of Paris Observatory; Dr. F. Hoyle, England; and Dr. M. G. J. Minnaert, Holland.

Dr. and Mrs. D. Chalonge, of Paris Observatory, photographed at the Jungfraujoch scientific station.

tories of the Swiss Federal Institute of Technology, or of Kern and Company, an optical works at nearby Aarau. Finally, as already mentioned in these notes last month, immediately after the Zurich sessions ended there were excursions to the coronagraph station at Arosa (in eastern Switzerland) and to the Jungfraujoch (in the Bernese Oberland of central Switzerland).

The hotel and scientific stations at the Jungfraujoch are in a dramatic setting. From Interlaken, in the heart of the warm, grass-clad lowlands, Swiss trains carried the astronomers, on a day which grew more perfect each hour, to the eternal winter of some of the highest Alps. The last part of the journey was through tunnel in the solid rock interior of the Eiger and Mönch mountains. At 11,340 feet, still inside the mountain, there is the five-story Berghaus, its windows on one side only, hundreds of feet above the head of the Aletschgletscher, the longest glacier in Europe.

Passageways in the rock lead to the saddle of the Jungfraujoch itself (from where the accompanying picture of the Sphinx was taken). But an elevator rises quickly to the indoor and outdoor observing platforms (open to the public) of the Sphinx. On the roof of this building is meteorological equipment and, at present, a 10-inch Cassegrainian telescope used by Dr. D. Chalonge for photographing the ultraviolet spectra of early-type stars. Late this year, the French astronomer will visit Texas to employ his equipment with the 82-inch McDonald Observatory reflector on the spectrophotometry of faint white dwarfs.

Also built in the rock, at the level of the Berghaus, is the main station, headquarters for high-altitude scientific research at the Jungfraujoch, and operated by the scientists of many countries. Cosmic ray equipment is at present being used by Egyptian physicists. Chinese scientists have been working on the influence of ultraviolet light on tuberculosis in mice; and work on cosmic rays and cancer in rats has been done at the Jungfraujoch. Cosmic rays and meteorology have been, perhaps, the subjects most intensely pursued. Below, on the glacier, a heated tube is inserted to a depth 150 meters below the surface to permit observation of the rate of flow of the "river of ice." The Hochalpinestation houses workrooms, living quarters for some dozen people, laboratories, and a library.

This plaque is mounted in the Sphinx Observatory at the Jungfraujoch.

The Sphinx Observatory.

Each train brings hundreds of visitors to the Joch. They lunch in the Berghaus, skate on the ice rink inside a glacier, walk out on the snow, or take a short dog sled ride. C. A. F.

In Focus

THIN FILMS of oil provide the bearing surfaces for the 500 tons of moving parts of the world's largest telescope, the 200-inch Hale reflector. Two of the four oil-pad supports for the horseshoe bearing at the north end of the instrument are shown in detail by Russell W. Porter's drawing on the back cover of this issue. In all there are seven oil pads, as three more are required for the hemispherical south polar bearing.

To overcome the enormous friction caused by turning the 500-ton mounting, Palomar engineers devised a forced-feed oil film to "float" each bearing. Because the rotational speed of the 200-inch is slow, the shearing force in the supporting oil film during motion is very small, which makes a reduction in friction of a thousandfold over that possible with roller bearings.

The oil-support system also eliminates excessive torsion in the yoke structure when it is driven at only one end. The coefficient of friction of the polar-axis bearing system alone is less than 4×10^{-6}. Consequently, only 50 foot-pounds of torque is required, and even with the gearing of other mechanism a small motor delivering less than 1/12 horsepower is sufficient for driving at tracking speed.

The drawing depicts the two northeast oil pads with the dust cover removed from them. Four gauges on each pad enable the engineer to check oil pressure, thickness of the film, and other mechanical factors. At the corners of the oil pads are safety micrometer oil-film switches which shut off right ascension control if the film thickness becomes less than 0.003 inch; or by means of indicating lights the micrometer film switches may be used to read the actual film thickness to 0.0003 inch.

At the left of the oil pads can be seen four scrapers that remove superfluous oil to a sump below, where a pump returns it to the pads. Similar scrapers in other positions perform the same duty. The oil films supporting the north and south polar bearings are under pressures ranging from 210 to 518 pounds per square inch. The pairs of oil-pad bearings are spaced 60 degrees apart under the horseshoe.

The bearing which floats on the film of oil is the mirror-smooth under surface of the 46-foot horseshoe. This unit alone weighs 317,000 pounds, more than one fifth that of the whole instrument. The cutaway in the drawing shows the ribbed interior construction of the horseshoe, which saves weight but does not sacrifice strength.

This horseshoe bearing is the most outstanding feature whereby the 200-inch departs from earlier telescope mounting designs. The ordinary yoke mounting has many advantages, but does not permit observation of the polar regions of the sky. Even after the horseshoe had been devised as a solution, its construction presented the serious problem of the deflection of its ends when the 200-inch telescope pointed far to the east and west of the meridian. If the outside of the 46-foot bearing were made circular, it would no longer remain so during extreme east or west observing positions.

Therefore, to overcome this difficulty, before the bearing was machined in the Westinghouse plant in East Pittsburgh the ends of the horseshoe were tied together with steel rods and a turnbuckle, a compression member was inserted deep in the horseshoe, and the ends were pulled together. The outside surface was then turned and polished to a true circle. When the rods holding the ends were released, this circle sprang into a shape which had been calculated to deflect just enough at all positions of the telescope.

TERMINOLOGY TALKS-- J. Hugh Pruett

Cometary Superstitions

From ancient times until the present many have considered comets certain forerunners of war and pestilence. About the year 1600 a German wrote: "Comets are formed by the ascension from the earth of human sins and wickedness, which develop into a kind of gas that is ignited by the wrath of God."

Erroneous surely is this theory, else during the first half of the present decade our night skies would have been flaming with the most horrible of these portents.

Halley's Comet

One prominent comet in particular has, during the past 2,000 years, appeared in the sky around the time of so many momentous historical events that those superstitiously inclined could easily suspect a connection between this celestial apparition and the terrestrial events. This is Halley's comet, whose name today is familiar to almost any high school student. The present year finds this cosmic traveler at aphelion, its greatest distance from the sun.

A comet usually bears the name of its discoverer, but this is not true of Halley's. Was it ever "discovered" in the orthodox manner? It had doubtless been making regular visits to our part of interplanetary space for ages before the earliest of preserved writings. Historical accounts indicate quite definitely that from 240 B.C. to A.D. 1910 every return but one is on record. The time for a complete trip around its elongated, oval orbit averages about 77 years, but the actual interval between any two appearances ranged from 75 to 79 years. The differences are due principally to the perturbations (disturbances) caused by the larger planets.

Edmond Halley, a brilliant English mathematician, observed a fine comet in 1682. His calculation of its orbit inspired him to determine the paths of many earlier comets concerning which he had considerable data. He was surprised that several seemed to travel in practically the same orbit. He wrote substantially as follows:

"Many things make me believe that the comet Apian observed in 1531 was the same which Kepler and Longomontanus more accurately described in 1607; and which I myself have seen return in 1682. All the elements agree, and nothing seems to contradict my opinion except the inequality of the periodic revolutions.... In the year 1456, in the summertime, a comet was seen passing retrograde between the earth and sun, which I cannot think different from those just mentioned. A comet was seen about Easter in 1305, or 151 years earlier. Hence I think I may venture to foretell that *it will return again in the year 1758.*"

Only 16 years before the predicted reappearance, Halley died, at the age of 85. Spring and summer of 1758 came — but no comet. Autumn passed and winter arrived. Was the keen mathematician mistaken? No! On Christmas night the amateur astronomer Palitzsch, a farmer near Dresden, Saxony, sighted the returning cosmic wanderer. Halley's prediction was gloriously fulfilled and opened a new era in cometary theory.

Twice since the return of 1758 (in 1835 and 1910) Halley's splendid comet has visited our region of the solar system. Many readers will recall the latest appearance. It was first photographed as an exceedingly dim object at Helwan, Egypt, on August 24, 1909. Perihelion (nearest approach to the sun) was reached April 20, 1910. Early in May it became a spectacular object in the east, with its extensive tail stretching fully 120° across the moonless, morning sky. On May 19 it passed between us and the sun, and was thereafter seen in the western sky.

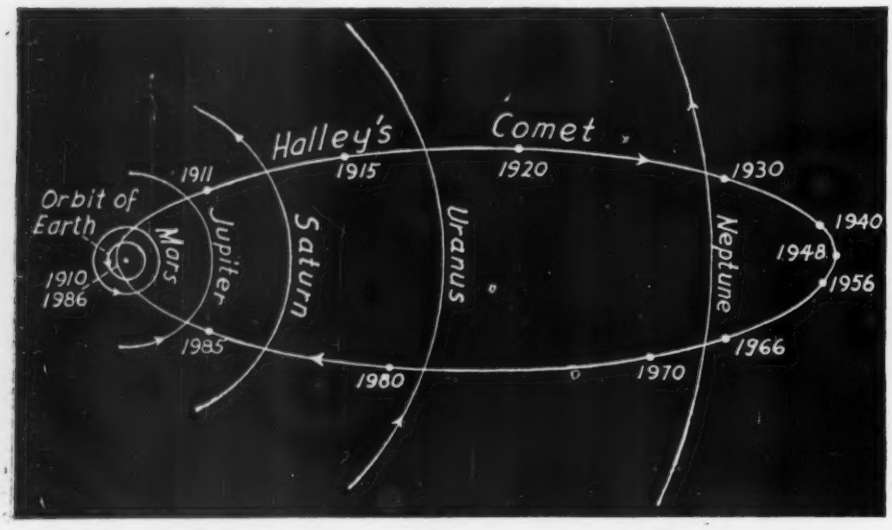
Halley's comet as it appeared to the naked eye in 1910, drawn by Luis G. Leon, in Mexico. Venus is the brilliant object at the right. From "Popular Astronomy," August-September, 1910.

Bright evening moonlight dimmed the comet's luster after it passed the sun. Residents of the Pacific Coast (and somewhat farther east) were, however, treated to a marvelous showing on May 23rd, when from 9 to 10 p.m. the full moon was blacked out by a total eclipse and in the clear western sky the comet with its gorgeous tail could be seen in all its glory. By early July, 1910, Halley's comet had dimmed below naked-eye visibility, but it was followed telescopically for about another year, and then was lost to sight.

This year Halley's comet is far beyond the orbit of Neptune and is just making the turn in its preparation for another long dash sunward. It is now moving at an astronomical "snail's pace," or only a little over one-half mile per second. The nearer it gets to the sun, the speedier it will become, so that when it rounds our central luminary at perihelion in 1986 it will be flying 34 miles per second.

It is estimated that the comet is now at about magnitude 30 in brightness. It will be recalled that the very bright stars are of magnitude 1; the dimmest visible without optical aid, 6; and the faintest that can be reached with the new 200-inch Hale telescope, 22.5.

Should one want to point out in the sky the present location of Halley's comet, rough calculations by a prominent astronomer indicate that this is somewhere near the junction point of the constellations Lynx, Leo Minor, and Cancer. However, no eye-straining should be indulged in with an expectation of seeing the comet.



The orbit of Halley's comet. After "Astronomy," by Skilling and Richardson.

A New Atlas of the Heavens

By Zdenek Kopal

Massachusetts Institute of Technology

One chart of the new Skalnate Pleso Atlas of the Heavens *is reproduced on the following pages, reduced from its original size of 23½ by 15½ inches. The complete atlas, with all charts full scale, will be published in the near future by Sky Publishing Corporation.*

HUMAN EFFORTS to reproduce on charts the apparent distribution of stars in the sky date back to time immemorial. To mention only one less well-known achievement in this direction: One of the chief titles to fame of the Korean king Li Ch'eng kuei appears to be the completion, under his orders, of a celestial planisphere in Seoul which (judging from the position of Polaris) was probably copied from a much older original, dating perhaps as far back as the early centuries before Christ. We know that the work commanded by the good king Li included 1,464 stars and was directed by Ch'uan chin; its computations were supervised by Lin fang tse, with at least nine collaborators on the project. The final copy, completed in 1395, was engraved on stone. The original engraving having been worn out, the work is known to have been engraved on another stone. This is what it meant, in those days, to produce a "new edition" of a star chart.

With the invention of printing (which, strangely enough, was already known to the Koreans of the Li period, but was probably not considered dignified enough to reproduce properly the splendors of the sky), the production and dissemination of star charts entered a new era and flourished widely. The most conspicuous example of the pretelescopic era is probably the *Uranometria* by Johannes Bayer, published in Augsburg in 1603, which on 41 large sheets contained charts of all northern and some southern constellations as tradition knew them in antiquity and the Middle Ages. As far as artistic beauty and splendor of engraving are concerned, Bayer's presentation has probably remained unsurpassed. But few libraries and still fewer individuals can boast possession of this now rare book. It has been partially resurrected, however, in a diminished edition prepared in 1938 by Josef Klepesta in Prague, Czechoslovakia.

The advent of telescopic astronomy naturally created an entirely new situation. The number of stars visible through telescopes of increasing power began to grow almost beyond limit and the search for asteroids, comets, and other faint objects created a demand for much more detailed star charts. The 19th century produced the magnificent set of charts based on the famous *Bonner Durchmusterung* and its southern Cordoba continuation — the most extensive charts prepared up to the present — recording the positions of almost all stars down to the 10th magnitude. These charts have now been out of print for many decades; but the BD catalogues were later used as a basis for several atlases of more modest size. The best of these is probably the Beyer-Graff *Atlas,* now also out of print, which covered the northern hemisphere and a part of the southern equatorial belt and was almost complete to stars of 9th visual magnitude. Its relatively small scale, however, made the maps overcrowded and less convenient for use. One of the most valuable modern compilations for the amateur is Norton's *Star Atlas,* which has had several editions.

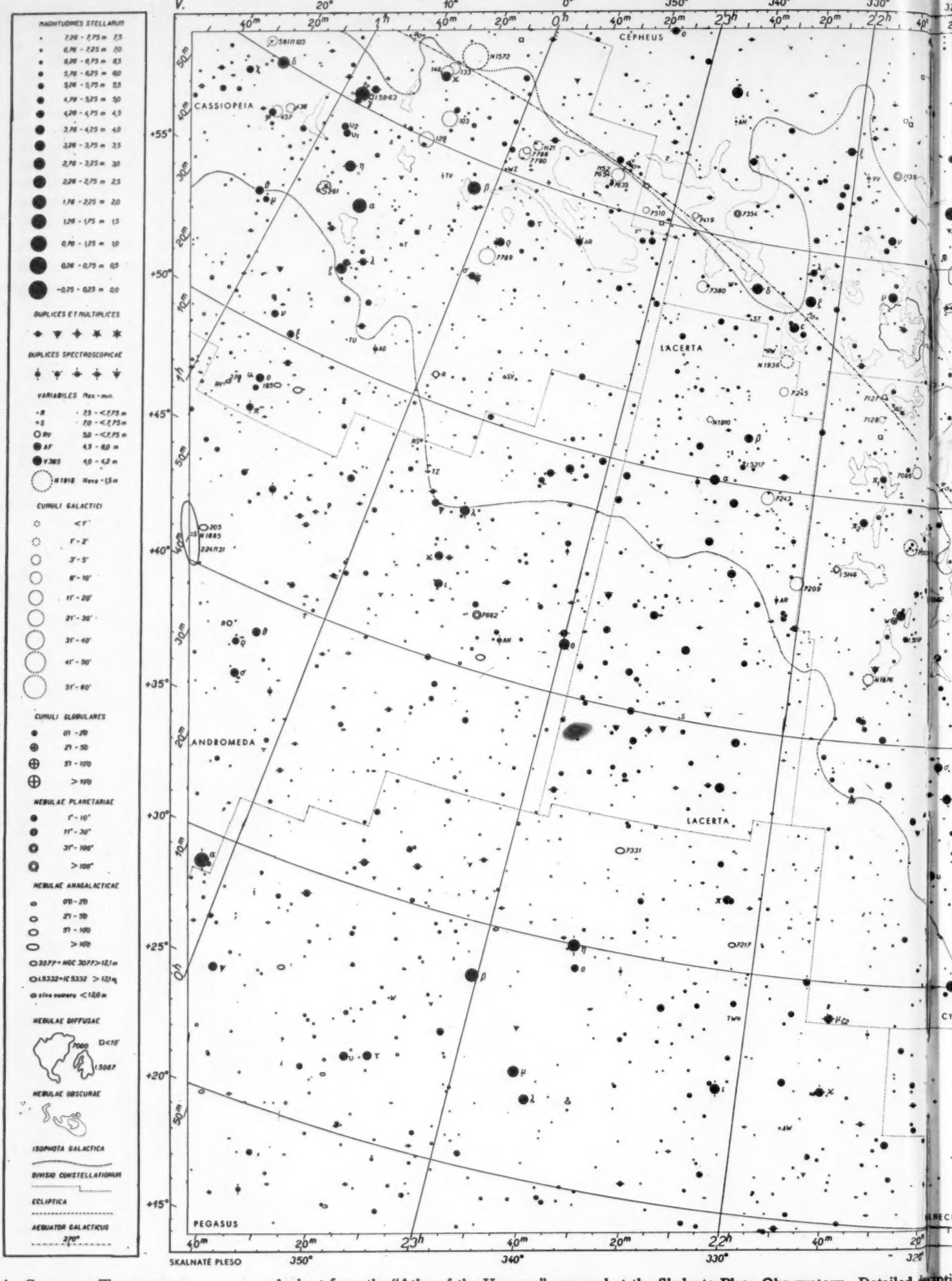
The new *Atlas of the Heavens,* from the Skalnate Pleso Observatory in Czechoslovakia, stands out among all its predecessors in several respects. It is the first atlas of the sky of its size which covers *both* celestial hemispheres in a homogeneous manner. On its 16 charts it shows positions of all stars down to 7.75 visual apparent magnitude for the equinox of 1950.0, taken from the Boss *General Catalogue* and the *Henry Draper Catalogue.* A total of 32,571 recorded stars ranks it third in size in the existing literature. It may perhaps be a matter of some regret that it did not prove possible to lower the limit of the faintest stars in the new atlas to apparent magnitude 8.2, to which the *Henry Draper Catalogue* is complete in both hemispheres. We understand that this possibility was indeed considered, but decided against because it would have postponed considerably the completion of the atlas and necessitated an increase in its scale and size, resulting in a work rather unwieldy and too expensive for the average user.

The new atlas — and this is important to emphasize—includes much more than mere positions of the stars. In the 19th century, positions were almost all that interested the celestial cartographer. A cluster or a nebular patch, which traversed now and then the field of a transit or meridian circle, evoked but little curiosity on the part of a self-respecting astrometer of bygone days; and an occasional lack of stars in the field was noted, we suspect, primarily as a respite from strenuous work. The magnificent efflorescence of astrophysics in recent decades, which led us gradually to exchange meridian circles for Schmidt cameras, has done much to alter the old attitude. Not only positions, but also the brightnesses of the stars are nowadays measured with accuracy, and the *Atlas of the Heavens* reflects this in a carefully graduated scale of images.

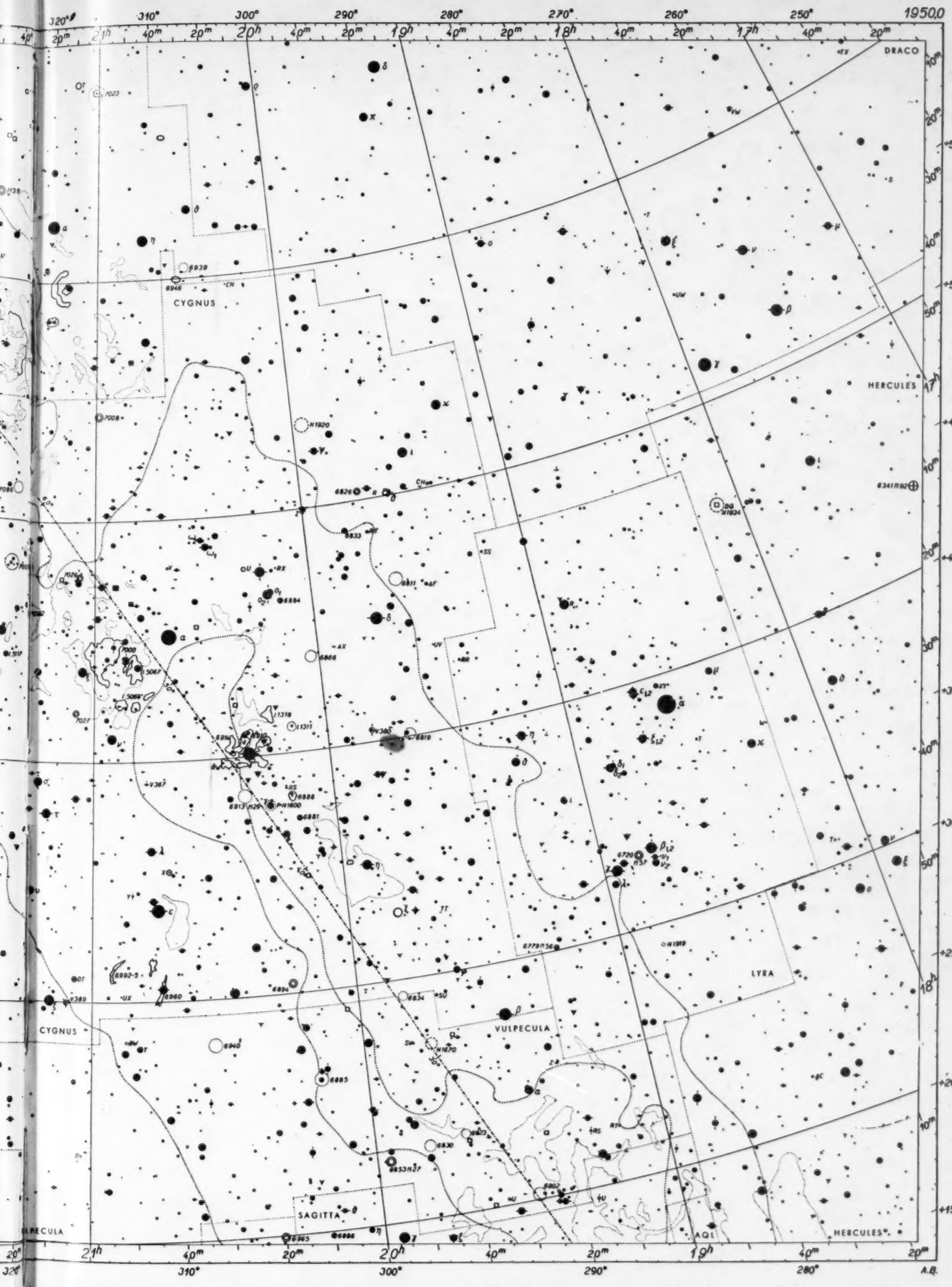
Almost one sixth of all stars included in the atlas are known to be double or multiple. Each one of these is marked on the chart in an appropriate manner, which permits its user to discern the number of components in the system, and whether the pair is a visual or spectroscopic binary. All known novae, and variable stars attaining at maximum visual magnitude 7.75 or brighter, 443 in number, are likewise marked as such. The atlas shows, furthermore, the positions and relative dimensions of 249 galactic star clusters (from Shapley's catalogue in *Star Clusters,* Cambridge, 1930, Appendix B); all globular clusters and planetary nebulae known up to the present; 1,121 extragalactic nebulae of magnitude 13.0 or brighter (according to the Shapley and Ames catalogue, Harvard *Annals,* Vol. 88, 1930); as well as 230 galactic gaseous nebulae, the larger of which are indicated by their characteristic shapes as revealed on actual photographs by different observers. The various star clusters and nebulae of apparent brightness greater than 12.0 are denoted on these charts by their respective numbers in the *New General Catalogue* (NGC) or the *Index Catalogue* (IC). Even the dark nebulae and obscuring patches on the sky — Herschel's "Loche im Himmel" — are marked on the charts with the same attention and care as are the luminous ones. The outlines of the Milky Way are shown according to the work of Pannekoek (*Die Noerdliche Milchstrasse,* Leiden, 1920; *Die Suedliche Milchstrasse,* Lembang, 1929), together with the position of the galactic equator referred to Newcomb's pole, and of the ecliptic. In addition, the limits of the constellations as outlined by Delporte and endorsed in 1930 by the International Astronomical Union are shown.

This wealth of information, which in many previous star charts and atlases was conspicuous by its absence, renders the new atlas unique. It should prove useful to the professional astronomer for his manifold tasks, and still more to the amateurs of both hemispheres — whether for the identification of double or variable stars, for the discovery of new comets among hundreds of known nebulae or unresolved star clusters, or for the choice of interesting objects for celestial photography.

Star charts and their preparation appear to belong to the astronomical tradition of Czechoslovakia; and of late most of them have been associated with the name of Josef Klepesta, a publisher and one of the leading amateur astronomers of his country. In the past 30 years he has published at least a dozen star charts and atlases of varying scope and purpose. In the list of Klepesta's



A chart from the "Atlas of the Heavens" prepared at the Skalnate Pleso Observatory. Detailed descriptio



d description of the key is given on page 16. Reduction here is about 3:2 from the scale of the original chart.

earlier publications, one particularly arrests our attention as the forerunner of this work, *Atlas de l'Hemisphere Celeste Boreal,* in two parts. The equatorial part by Schueller appeared in 1926 on the occasion of the 10th anniversary of the Czechoslovak Astronomical Society in Prague, and the polar part was completed by Novak four years later. This atlas won the Henri Rey prize of the Société Astronomique de France in 1927, and a good many of its copies found their way abroad though, apparently, only a few to the United States.

In the past 15 years or more the work has been completely out of print. In face of an increasing demand for it, a new edition was first considered after the war; but later it was decided to redraw and improve it on a much larger scale. The initiative originated again with Klepesta; but this time the idea was taken up by Dr. Antonin Becvar, director of the new astrophysical observatory at Skalnate Pleso (Rocky Lake) in the High Tatra Mountains. It was Becvar who planned the work, and carried it through to a successful conclusion, assisted by an enthusiastic group of volunteers — among whom he names Mrs. Klara Becvarova, Miss Nada Blahova, Milan Dzubak, Michal Forgac, Lubor Kresak, Miss Vera Chmelarova, Josef Klepesta, Miroslav Plavec, Jaroslav Siroky, Bedrich Vadovic, and Miroslav Vanysek. The whole work, which required almost 3,000 man-hours to complete, was carried through in less than one year, and is a tribute to Becvar's energy and skill, and to the devotion of his collaborators.

The first copies of Becvar's *Atlas* appeared in Prague this summer, in commemoration of the 30th anniversary of the astronomical society, which has grown up into one of the largest organizations of its kind in the whole world. (See *Sky and Telescope,* V, 9, July, 1946.) A shortage of paper limited the copies that could be printed to a number which will scarcely cover home consumption, but an independent edition is now on the press in the United States, to be available to astronomers in all corners of the world. It is my conviction and hope that the usefulness of Becvar's *Atlas* to amateur and professional astronomers alike will continue for a long time to come. May the names of its author and his collaborators go down in history as did the names of the Korean astronomers headed by the learned Ch'uan chin, who completed the famous star chart of 1395.

Across centuries and continents we recognize in both groups of workers one quality in common: a selfless devotion to work destined primarily to serve others in furthering the celestial explorations which transcend all barriers of time and language, and constitute a continuous and cumulative effort of mankind.

THE KEY TO THE "ATLAS OF THE HEAVENS" CHARTS

Stellar Magnitudes are represented by symbols which range by half magnitudes from 7.5 to the brightest stars. For instance, 0.0 stands for stars of apparent visual magnitudes between −0.25 and +0.25, while 7.5 stands for stars between 7.26 and 7.75. It is suggested that for ease and accuracy of comparing magnitudes a template be constructed which can be placed directly over the images on the chart. This might be drawn in India ink on tracing paper or made by punching holes the proper size in a thin sheet of plastic.

Double and Multiple Stars are next on the key, and are indicated by bars or lines extending out from the star image. A line straight through a star, giving two projections, one on each side, represents a visual double. Three, four, five, and six bars indicate stars with that number of visual components. Note that for visual systems the projecting line is in contact with the star image.

Spectroscopic Doubles. At the left in the key is first indicated a spectroscopic binary of two stars, but the projecting lines do not touch the star image itself. The second symbol represents a spectroscopic triplet. The third image in this key shows a regular visual double with one spectroscopic component; the fourth, with two spectroscopic components — a quadruple system. The last is a triple visual system with one of the components spectroscopic.

Variable Stars. All variables which attain a magnitude of 7.75 or brighter are indicated. The letter or number of the variable is given as shown by examples on the key, and the type and size of the image denotes its magnitude or its variation. The smallest star symbol with a variable's designation is for stars that reach the chart limit when at their brightest. Next, stars that attain 7.0 at maximum are shown by open circles the size of 7th-magnitude symbols. Similarly, stars reaching other magnitudes at maximum are indicated by open circles of commensurate size, as in the case of "RV" in the key, which attains a maximum in the 5.0 range.

When the range of a variable is within the limit of chart magnitudes, the symbol is composite, the outer circle indicating maximum brightness and the inner the magnitude at minimum. Where the range of the variable is very small, however, as in "V365" in the key, the white ring is made as narrow as it is possible to reproduce.

Novae are indicated by dashed open circles, the diameter equaling the magnitude at greatest brilliancy of the nova, and the date giving the year of its outburst. If any diffuse nebula is associated with a nova, it is indicated — see Nova Herculis, DQ, N1934, Chart V (reproduced on pages 14 and 15), where the associated nebulosity is less than 10 minutes of arc in extent.

Concerning star symbols in general, it is important to note many instances on bright stars of what might at first seem a defect — a small white ring on the star disk. Vega is a good example, marked Alpha Lyrae on the chart. This star's symbol is almost one degree of declination in size, which would obscure the neighboring 7th-magnitude star. Therefore, in such cases, a ring of white around the fainter star permitted plotting its position. In the same region, Epsilon Lyrae is shown as a "naked-eye" double of two stars, with bars to indicate that each of the stars is again a telescopic double. The "1, 2" refers to Epsilon^1 and Epsilon^2, the designations of the two components. Delta Lyrae is shown as a naked-eye double, with one of the components a telescopic double and the other a spectroscopic binary. Stars that do not appear round should be examined closely as it is probable they are composite images.

Galactic Clusters are shown for apparent diameters from less than one minute of arc up to 60 minutes (one degree), for several ranges of size. Do not confuse such clusters with novae: clusters are **dotted** circles, novae are **dashed.**

Globular Clusters of various sizes are represented by open circles with vertical and horizontal bars inside them.

Planetary Nebulae are represented from one second to greater than 100 seconds of arc by two open, concentric circles. No indication of brightness is given.

Extragalactic Nebulae or **Galaxies** have a key given in two parts. The first shows that elliptical images in four size ranges mark these objects, up to 10 minutes of arc. Those that are greater are shown in their proper sizes. For instance, at the left edge of Chart V is the Andromeda nebula, about two degrees along its major axis, and its companion galaxy NGC 205. The second part of this key explains the catalogue designations for **New General Catalogue** (NGC) and **Index Catalogue** (IC) objects, with the Messier number if a galaxy has one. Objects fainter than magnitude 12.0 are given without numbers, the chart limit for extragalactic nebulae being 13.0.

Diffuse Nebulae (bright nebulosities) are given NGC and IC designations and their sizes and extents are indicated directly on the chart. The North America nebula (near Deneb on Chart V) is used as an example in the key. Nebulosity smaller than 10 minutes of arc is shown by a small square.

Dark Nebulae have light dotted lines to show the shape of the nebulosity.

Milky Way Boundaries are in heavy dotted lines.

Constellation Boundaries are represented by light lines of short dashes, and some constellations are labeled several times to avoid confusion.

The **Ecliptic** is a heavy dashed line.

The **Galactic Equator** is a line of alternate dashes and dots, with the galactic longitude marked at 10-degree intervals.

Positions of objects in the chart may be accurately measured from their plotted symbols. Right ascension lines are straight, and a straightedge may be used to join markings from top to side of the chart, as well as from top to bottom. Right ascension is given in both time units and arc units. Declination lines are arcs of equally spaced circles. Consequently, a declination scale made to any degree of accuracy may be applied to any portion of the chart.

Amateur Astronomers

AMATEUR ACTIVITIES THROUGHOUT THE COUNTRY

A lecture course entitled "Observational Astronomy" is being conducted by members of the **Amateur Astronomers Association of Pittsburgh** at the Buhl Planetarium. November sessions are to be held on the 5th and 19th. Topics being covered are terms and definitions; telescopes and observing methods; star maps and sidereal time; the solar system; stars, nebulae, and galaxies. Lecturers are Glenn A. Winterhalter, Leo J. Scanlon, H. Malcolm Priest, Willard A. MacCalla, and Charles H. LeRoy. A course in advanced astronomy is planned for the spring.

The Messier Club of the **Montreal Centre** of the Royal Astronomical Society of Canada continues to arouse interest among the centre's members, 19 of whom are taking active part. DeLisle Garneau leads with the observation of 83 Messier objects to his credit, and Mrs. Gwenda Hall holds second place with 41. All but five of the 19 Messier observers have 10 or more Messiers to their credit. The observatory of the centre, situated at 4052 Wilson Ave., Notre Dame de Grace, is open every Saturday evening, when members are invited to bring their friends.

The traditional series of public nights held at the **Warner and Swasey Observatory** of the Case Institute of Technology is again under way. The observatory, which is located in East Cleveland, Ohio, is open on scheduled Thursday and Friday evenings at 7:45 p.m. The lecture is at 8:00, with observing afterwards. Reservations may be had through the Case Institute, at TYler 1-1000, and group reservations at GL-5625. On November 11th and 12th the lecture topic is "The Sun and Its Motions." The December 2nd and 3rd lecture is on "The Winter Sky."

Nine youngsters of **Ft. Worth, Tex.**, ranging from eight to 12 years old, recently qualified as junior astronomers in the Children's Museum junior astronomy club program. The list of goals to be achieved was: 1. Read and be able to give a brief report on at least five books on astronomy on your reading level. 2. Know 20 constellations; make records of observations of them, the time of observation, date and location. 3. Know and be able to locate at least 15 stars of 1st magnitude. 4. Make a scrap book on astronomy; include pictures and clippings. 5. Make a shadow box with at least 10 slides. 6. Chart the positions of Jupiter, Mars, and Saturn among the stars over a period of four or more weeks, and state the limiting dates of observations; indicate with an arrow the direction each is moving. Membership and regular attendance for one year is also required for qualification as a junior astronomer.

New officers of the **Stamford Amateur Astronomers** are Richard Hamilton, chairman, and Clair Beegle, vice-chairman, with William L. Dutton continuing as secretary. The November and December meetings of the Connecticut group will be on the **third** Friday instead of the regular fourth Friday, at the Stamford Museum at 8 o'clock. Over 60 persons attended the September meeting, and the club has a requested mailing list of 132 names.

On the evening of August 28th, 30 members and guests of the **Sacramento Valley Astronomical Society** traveled to the Gold Discovery Site at Coloma for an outdoor supper and an evening of observing. Telescopes set up included A. L. Byers' 2-inch refractor, an 8-inch RFT by H. Simmonds, C. A. Fogus' 4-inch refractor, an 8-inch reflector made by Dr. Robert Smith, and a battery of photographic cameras assembled by P. T. Nesbit. Jupiter, the Ring nebula, and Milky Way clusters and nebulae were well observed in the smoke-free, dark sky. Several of the group secured star-trail photographs with their cameras.

At the **Madison Astronomical Society** meetings, held at the Washburn Observatory of the University of Wisconsin, general discussion of current astronomical events precedes the lecture, and constellation study on the observatory lawn is also conducted on meeting nights.

THIS MONTH'S MEETINGS

Chicago: "Recent Solar Eclipses Used to Determine the Shape of Our Earth" is the topic of the lecture by E. A. Halbach, director of the Milwaukee Astronomical Society Observatory, before the Burnham Astronomical Society, on Tuesday, November 9th, 8 p.m. at the Chicago Academy of Sciences. This is the annual meeting, and there will be election of officers.

Cleveland: On November 19th, at 8 p.m., Dr. J. J. Nassau, of the Warner and Swasey Observatory, will speak to the Cleveland Astronomical Society on "The 200-inch Telescope." The meeting is at the Warner and Swasey Observatory.

Columbus: Dr. Geoffrey Keller, of Perkins Observatory, will be the speaker on November 30th to the Columbus Astronomical Society. His subject is "The Milky Way and Other Galaxies." The meeting is at 8 o'clock at the McMillin Observatory.

Geneva, Ill.: The Fox Valley Astronomical Society, meeting on Tuesday, November 2nd, 8 p.m. in the Geneva City Hall, will hear a demonstration lecture by C. G. Davidson on "Astronomical Photoelectric Cells."

Indianapolis: "Stars and Mathematics" will be discussed by Dr. Harry E. Crull, of Butler University, at the November 7th meeting of the Indiana Astronomical Society, at 2:15 p.m. in Cropsey Hall.

Kalamazoo: On November 6th at 8 p.m., the Kalamazoo Amateur Astronomical Association will meet in the Science Hall of Kalamazoo College, when Dr. John Hornbeck will speak on "Cosmic Rays." There will be election of officers.

Madison: The Madison Astronomical Society will meet on Wednesday, November 10th, at the Washburn Observatory at 8 o'clock, when "The Milky Way" will be discussed by E. P. Baillie.

New Haven: "Astronomical Oddities" is the subject of a talk to be given by David W. Rosebrugh, of Waterbury, Conn., at the November 29th meeting of the New Haven Amateur Astronomical Society, 8 p.m. at the Yale Observatory.

New York: Dr. John S. Hall, of the U. S. Naval Observatory, will speak on "Measuring Starlight" at the meeting of the Amateur Astronomers Association, November 3rd, 8:00 p.m. at the American Museum of Natural History.

Philadelphia: "Astronomy in Europe" will be described by Charles A. Federer, Jr., Harvard College Observatory, at the Rittenhouse Astronomical Society, Morgan Physics building, 8:30 p.m., Friday, November 12th.

Pittsburgh: The November 12th meeting of the Amateur Astronomers Association of Pittsburgh will be addressed by Dr. O. E. Jennings, of the Carnegie Institute, whose subject is "Presque Isle, the Peregrinating Peninsula." The meeting is at the Buhl Planetarium at 8 o'clock.

Stamford: The Stamford Amateur Astronomers gather this month on Friday, November 19th, in the Stamford Museum at 8 p.m. "Tycho Brahe's Early Astronomical Instruments" will be discussed by L. C. Eichner, of Bloomfield, N. J.

Washington, D. C.: Clay P. Butler, physicist at the Naval Research Laboratory, will speak to the National Capital Astronomers on Saturday, November 6th, at 8:15 p.m. in the Commerce Department auditorium. His subject is "The Greenhouse Effect and Planetary Temperatures."

INCLINATIONS OF SPECTRUM LINES IN SPIRALS

(Continued from page 5)

until more observations are made, particularly for the main bodies of the early- and intermediate-type spirals.

A sample calculation for NGC 1332 is briefly: This galaxy has a red shift, corrected for galactic rotation, corresponding to +1,300 kilometers per second. Since Hubble found that the red shift increases 526 kilometers per second per million parsecs, the estimated distance of NGC 1332 is 1,300/526, or 2.5 million parsecs — about eight million light-years. The period of rotation is then obtained from the simple formula:

Period/Distance = Constant/Inclination.

The constant depends on the telescope's focal length, prismatic dispersion, and other quantities. For the Crossley nebular spectra shown here, and for the H and K lines, the constant equals 12.6. Hence, for NGC 1332, in which the H and K lines are inclined 5°.4, the period of rotation is $(12.6/5.4) \times 2.5 \times 10^6$, or 5.8 million years. Since this galaxy is oriented nearly edge on, no correction for tilt of its fundamental plane of rotation is required.

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BOOKS AND THE SKY

ASTRONOMIE

Les Astres, l'Univers

Lucien Rudaux and **Gerard de Vaucouleurs.** Librairie Larousse,* Paris, 1948. 486 pages. Price not supplied.

IT MIGHT SEEM UNUSUAL to devote so much space to the review of a book published in another language, but I hasten to say that even the reader who does not know French well would enjoy this new volume considerably. The Larousse publishing company has always been known in France and abroad for the abundance of excellent illustrations which constitute one of the main features of its publications.

For those who understand French, the text will be an invaluable source of up-to-date information presented in such a fashion that it can be read with equal profit by the amateur as well as the professional astronomer.

The writing of this book had been undertaken by Lucien Rudaux, director of the small private observatory of Donville, who died before completion of the work. At the request of his widow, Dr. Gerard de Vaucouleurs, of the Paris Observatory and the Institute of Astrophysics, agreed to edit and complete what was already written and to write the second part of the book. In his foreword, Dr. de Vaucouleurs informs us that he attempted to bring his material up to date as of the middle of 1947.

The first chapter, "Aspect of the Sky," considers briefly the various kinds of celestial bodies, their appearance to us and the physical laws they obey. Next, "The Sun's Empire" offers a most complete and detailed survey of our present knowledge of the planetary system. After a quick general summary, the earth is considered first, its shape, atmosphere, and physical phenomena. The moon is described, with a popular discussion of many problems connected with its study — the absence of water and atmosphere, hypotheses on the formation of its surface features, its habitability, and so forth. Numerous beautiful pictures of lunar features and a map of the moon make useful complements to the chapter. Eclipses, occultations, and tides are a natural sequence to the study of the moon; little space is devoted to them, but the facts are described very clearly with excellent diagrams.

The chapter on planets is perhaps the most striking and fascinating of the whole book. Dr. de Vaucouleurs is an expert on planetary observations, and has assembled here an invaluable amount of information. Many of his own drawings of planetary surfaces help make this part of the book very engrossing reading. A short chapter on comets and one on meteors and meteorites present classical facts as well as an account of more recent work, including radar experiments.

The treatment of the solar theory is maybe not as up to date as might be expected, and the emphasis is on such subjects as sunspot cycles, whereas the discussion of ionospheric phenomena remains sketchy and little in keeping with the rest of the book. There are numerous diagrams illustrating solar rotation and the formation of sunspots according to different theories.

The second part deals very competently with the universe of stars. Some more technical parts of the text will require concentration from the nonprofessional reader, well worth the effort, for one finds here an overall survey of problems in the study of individual stars and stellar assemblies. Basic facts concerning binaries and variable stars are followed by an excellent discussion of present concepts of stellar constitution and the generation of stellar energy.

The sizable format of the book makes possible many large and beautiful illustrations of the Milky Way and extragalactic nebulae — possibly the most attractive portions of the book are here. "Past and Future of the Universe" presents the modern notions on the cosmic time-scale and various theories concerning the evolution of the universe, the formation of the solar system, and stellar evolution.

The last two chapters are dedicated to the instruments and methods of astronomy. Pictures and diagrams of the largest telescopes illustrate the general properties of optical systems whereas complementary equipment — microphotometers, photocells, and the like — is described in connection with the problems in which it finds special use. The principles of spectral analysis and its numerous applications are treated last.

All in all this is an excellent book which should be thoroughly enjoyed. I regret, however, that the authors did not think it necessary to give any references, particularly since this publication is destined mainly for the nonprofessional reader, who might have some difficulties in locating original articles.

SIMONE DARO GOSSNER
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THE "APPLICATION" OF TELESCOPES: 1667 OR 1668?

(Continued from page 7)

were carried on by Picard and his associates with the aid of a new 38-inch quadrant and other instruments equipped with telescopic sights.* Thus it was by means of the ambitious project which heralded the dawn of precise observational astronomy that Picard's confidence in his new sights was first publicly vindicated.

In 1671, as Picard prepared the *Mesure de la Terre* for publication, the application of telescopes to astronomical instruments was an established scientific fact. To be sure, knowledge of the new invention might be disseminated only slowly, for the higher administration of the Académie was jealous of the discoveries of its members. Moreover, a decade or more might have to elapse before staunchly conservative astronomers would be prepared to adopt the new instruments (the great Hevelius, who died in 1687, refused to have anything to do with them). Nevertheless, approximately four years after the obscure early experiments with lenses were begun in Paris, open sights were obsolete.

Such, briefly, is the history of the application of telescopes to astronomical instruments as it emerges from a careful scrutiny of the evidence now known to us. An attempt to reconstruct these events has long been in order. The subject is important enough to deserve a brief monograph. Until this can be published, readers interested in the original or primary sources of information for the application, and in the details of the critical operations to which these sources have been subjected in connection with the writer's investigations, will need to consult his article, "History Without Historical Method: An Example from the History of Astronomy, 1741-1941," to appear in the quarterly journal of the History of Science Society, *Isis*, Vol. 39, 1949.

*These instruments may be seen in detail in the splendid illustrations which accompany Picard's account of the earth's measurement, first published ostensibly in 1671, and afterward reprinted in the 18th century in the *Histoire et Memoires de l'Academie Royale des Sciences depuis 1666 jusqu'a 1699.*

NEW BOOKS RECEIVED

THE STARS ARE YOURS, *James Sayre Pickering*, 1948, *Macmillan*. 264 pages. $3.95.

The beginner in astronomy and constellation study will find this non-technical book aimed just right, written by the son of the late well-known amateur astronomer David B. Pickering.

NEWTON TERCENTENARY CELEBRATIONS, *Various authors*, 1947, *Macmillan* (Cambridge University Press). 92 pages. $3.00.

A collection of the lectures given in July, 1946, at the week-long celebration of Newton's birth, sponsored by the Royal Society, in which delegates from 35 countries participated.

CENTENNIAL SYMPOSIA, *Various authors*, 1948, *Harvard Observatory*. 385 pages. $5.00.

The complete papers from the Harvard Observatory centennial symposia held in December, 1946, including the first Henry Norris Russell lecture. Symposium titles are: Interstellar Matter, Electronic and Computational Devices, Eclipsing Binaries, The Gaseous Envelope of the Earth.

ELECTROMAGNETIC WAVES AND LIGHT, *Charles F. Meyer*, 1948, *Ulrich's Book Store*, Ann Arbor, Mich. First part, 83 pages. $1.35.

Assuming a background in college physics, with some training in calculus, this treatise is intended for students in the physical sciences and for biologists who wish to understand the nature of such electromagnetic waves as X-rays.

SPROUL OBSERVATORY, 1948, *Swarthmore College*, Swarthmore, Pa. 20 pages. Free.

This illustrated booklet gives the history of the founding of Sproul Observatory, with descriptions of its present buildings and equipment. The current research, observing, and teaching programs in astronomy at Swarthmore College are discussed in some detail. Dr. Peter van de Kamp, director of the observatory, states that a copy of the booklet will be furnished upon request to any interested person. Write Sproul Observatory, Swarthmore College, Swarthmore, Pa.

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By Allyn J. Thompson

LAPS for correcting or altering the figure of the secondary are shown in Fig. 24. A ring lap similar to that at **a**, having a mean diameter equal to about two thirds that of the secondary, is used to convert a spherical figure into a hyperboloidal one, the effect of the localized zonal polishing being to flatten the convex crests of apparent shape **b** in Fig. 13. If, on account of faulty technique, the

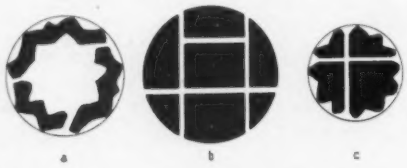
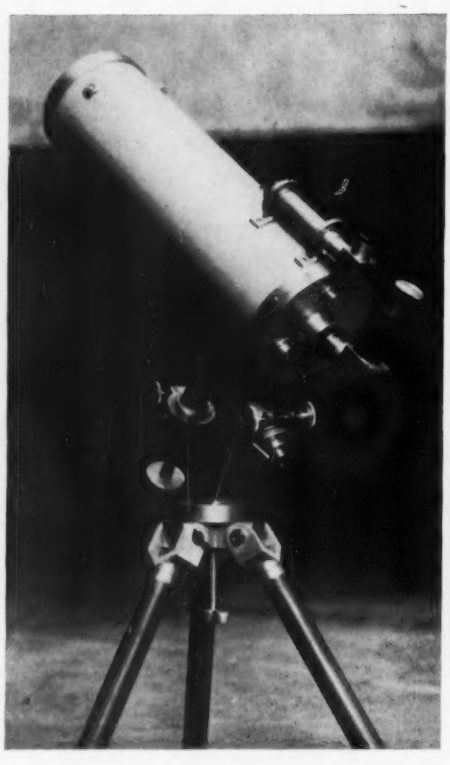


Fig. 24. Laps for controlling the figuring of the secondary.

surface becomes deformed, it can be returned to a spherical figure by polishing on top of it with a full diameter lap like that at **b**, Fig. 24. Normal polishing strokes bring this about without special effort because of the short radius of curvature of the secondary. By reversing the positions of lap and secondary, and choosing a stroke that will concentrate the polishing more or less at the center, undercorrection can be reduced. In both of these instances, the strokes should at first be kept short until their effect is observed under test, after which they may be lengthened if necessary. Undercorrection can also be treated by polishing on top with a smaller diameter lap, like the one at **c**, Fig. 24. It is particularly useful for removing a central hill without materially affecting the rest of the figure.



A Cassegrainian telescope made in accordance with methods described in this series of articles.

IMPROVED TESTS FOR SHORT-FOCUS MIRRORS

THERE IS NO DOUBT that Foucault's shadow test on telescope mirrors is, as Russell W. Porter says in **Amateur Telescope Making,** "one of the most delicate and beautiful tests to be found in the realm of physics." As we have pointed out, however (Part II of this series, page 211, June, 1948), on mirrors of short focus such as used in Cassegrainian telescopes the precision required frequently calls for greater finesse in shadow testing than the average mirror maker can achieve. A practiced operator can probably measure the correction of a mirror to 0.005", but many amateurs may wander by as much as four times this amount. As shown in Table II, the tolerable correction error in an f/4 mirror amounts to 0.011", and is only 0.006" in an f/3. Production of well-figured mirrors of low focal ratio has been accomplished only by a favored few with unusual aptitude for testing.

In the improved methods of testing described here, the author believes he has found the means for any amateur, after practice, to equal or excel the best efforts possible with the Foucault test on mirrors of low focal ratio. Zonal masks are employed, with only one pair of openings in each mask unless exposure shields are used. In Fig. 25 the dotted arcs indicate the center of the zone for which each opening is made. The widths of the slots depend on the radius of curvature of the mirror, narrower for shorter radii, ¼" being about right for a radius of 48 inches. Particular care should be had in accurately cutting the slots, exposing equal widths on either side of the zone center. Except as will later be described, neither the mirror's extreme edge nor its center zone can be included in these tests. Mask **b** is for the innermost useful zone, ordinarily of about one fourth the radius of the mirror. The testing mechanism required, briefly described later, is no more complex than that required for accurate Foucault work.

In Fig. 26, a mask is used to test the zone **bb′** of a mirror. The diffraction images formed from the mask openings are sharpest at **m** and **n**, which points are the true centers of curvature of zones **b** and **b′** respectively.* The radii of zones **b** and **b′** are **bm** and **b′n**, and their intersection **B** with the optical axis is what we try to locate in measuring corrections of the mirror. The pinhole image found at the point of intersection is in reality a combination of the diffraction patterns formed by zones **b** and **b′**, which are coincident in that plane. Since the distance **Bn** is relatively small and the angles involved

*Points **m** and **n** are the same as those for which the positions are measured in the Gaviola test, described in **Sky and Telescope,** I, 3 and 4, January and February, 1942. ED.

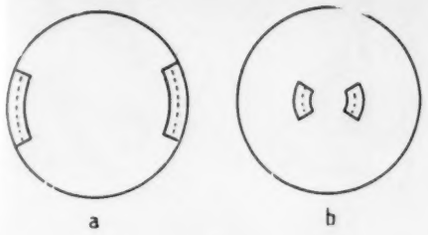


Fig. 25. Masks for testing the inner and outer zones of the mirror.

are small, similar patterns exist at **A** and **C**, respectively, but they are separate and tangent to each other. The distance between **A** and **B** is equal to the correction between zones **aa′** and **bb′**; similarly for **B** and **C**, **bb′** and **cc′**. If the zonal width is kept small, **B** may be assumed to be situated midway between **A** and **C**, within the errors of measurement of these tests.

If an eyepiece of not more than about ½-inch focal length is used to focus on plane **mn**, two separate images will be seen in sharp focus. As the eyepiece is moved along the axis toward the mirror, these images will approach each other, become tangent in the plane of **C**, coincide in **B**, and be tangent on their opposite sides at **A**. If the points of image coincidence can be accurately located for different zones of the mirror, and the differences between these points closely measured, we have here a positive method for determining correction. Actually, except perhaps when testing the mirror's outer zone, there is no visible difference in the appearance of the apparently coincident images over a range of at least 0.01″, which is little if any improvement over Foucault measurements.

The Bracket Test. For the actual testing operation, a slit is recommended rather than a pinhole, especially because it is easier to provide it with adequate illumination. My personal preference is for an eyepiece of ¼-inch focal length. For convenience of description, slit images lying between **B** and the mirror will be referred to as "inside of focus," and those on the other side of **B** as "outside of focus."

It is perhaps best to begin the test on the mirror's outer zone, as in Fig. 25, **a**. Assuming the slit source placed as in the Foucault test, the testing apparatus should first be adjusted so that both diffraction images are seen simultaneously

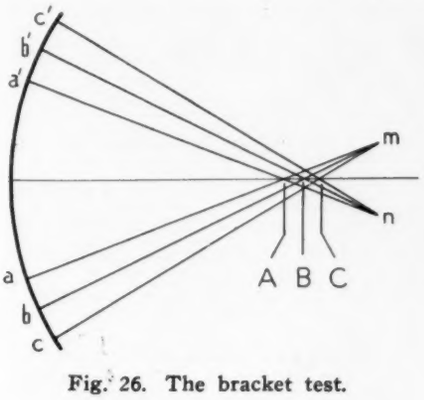


Fig. 26. The bracket test.

through the eyepiece, either outside or inside of focus. Each image consists of a bright vertical band, paralleled by two or more faint diffraction lines on either side (**a**, Fig. 27). When first viewed, the images may appear widely separated, but by moving the eyepiece toward or away from the mirror the central bands of the diffraction image can be made contiguous, so that duplicity is distinguishable only by the presence of a vertical dividing shadow, faintly seen as at **b** in Fig. 27.

As the eyepiece is moved still closer to the zonal "focus," this dividing shadow becomes less distinct and finally vanishes, when an apparently single image is seen. Our purpose is to select points on either side of focus in which the intensity of the dividing shadow is identical. Eyepiece power should be sufficient to permit observing dual images even when very close approach to coincidence is obtained. The

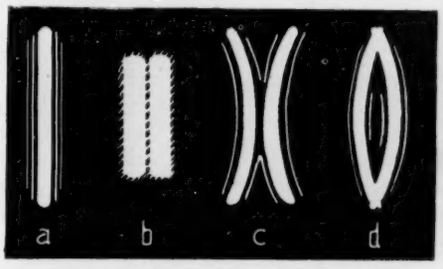


Fig. 27. Slit diffraction patterns.

dividing shadow should be just distinguishable. Selection of these reference points inside and outside of focus is not a difficult matter, nor is it likely to lead, as might be thought, to large error. For any zone an eyepiece movement of only 0.005″ conspicuously alters the appearance of the dividing shadow.

Indications from the writer's experiments are that for the outer zone of an f/4 mirror **B** can be located within 0.002″. For the innermost zone, the radius of which is equal to 25 per cent of that of the mirror, **B** can probably be fixed within 0.003″. The total error in measuring the correction between these two zones should not exceed 0.005″. An average of several measurements should be taken for each setting. It is only necessary then for the amateur to apply the required skill in figuring to assure himself of a mirror that is within an eighth of a wave length of the desired shape.

While the mirror may thus be tested and figured without scanning its surface, recourse must be had to the Foucault shadow test to check for surface texture and the like. But many workers will prefer to base the figuring procedure entirely on the shadows, and the following is a method of correlating the two tests.

The Eclipse Test. For this purpose, the magnification from a low-power eyepiece is inadequate, and with higher powers the cell of the usual two-lens ocular obstructs passage of the knife-edge. I there-

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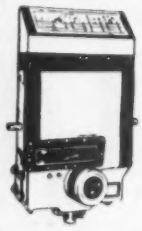

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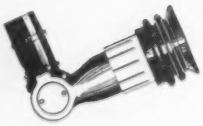

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fore removed the eye lens from a ½-inch eyepiece and mounted it in a lump of modeling clay stuck to the top of a pedestal just back of the knife-edge. The focal length of this lens was ⅝", but ½-inch focus might be superior. Too high a power will lessen the sensitivity, owing to a loss of contrast. Distortion in the single lens causes an apparent bending of the slit images, severe for the mirror's outer zone, as shown in Fig. 27, **c** and **d**. (Two plano-convex lenses, each of about 1-inch focus, mounted with their convex surfaces all but touching, have the requisite power and correct the distortion, but all four surfaces should be fluoride coated unless a very brilliant light source is available.)

The eclipse test consists of first positioning this eye lens independently of the knife-edge and focusing it on the separate diffraction images approximately in the plane of **C**. The slit images appear separated by about the thickness of either, somewhat as in Fig 27, **c**. If the knife-edge is brought to the same plane and cut in there **from the left**, the left-hand image will be obscured first. But if the knife-edge is in the plane of **A, with the eye lens still focused at C**, the right image will be covered first. Only when the knife-edge is cut in at **B** will both images be simultaneously extinguished. Having thus located the knife-edge precisely in the plane of **B**, we have only to remove the eye lens in order to observe the shadows on the mirror.

The moment of entrance into the diffraction image of the black knife-edge shadow is difficult to detect — there is only a narrowing of the diffraction pattern that may not be immediately apparent. Furthermore, the lack of contrast makes it impossible to determine, when the knife-edge is very close to focus, which image the shadow has entered first, or in which image the shadow is in advance. The observer must be alert, therefore, when the images have narrowed to slits, and extinction is imminent, to see if one is extinguished before the other. The rate of knife-edge motion across the point of zonal focus should be slowed to a crawl at this stage, as the last thinning glimmers of light slowly vanish.

In practice, the knife-edge is moved in slowly at right angles to the mirror's axis, and halted when its shadows are about half way through the images, the final cut-off being effected if feasible by applying downward finger pressure on the right-hand side of the testing bench. Better control may be had in this way, and one's entire attention can be concentrated on watching for the moment of eclipse. The knife-edge plane is gradually corrected until simultaneous eclipse of the images has been achieved. A comparison check on what has been seen can be made

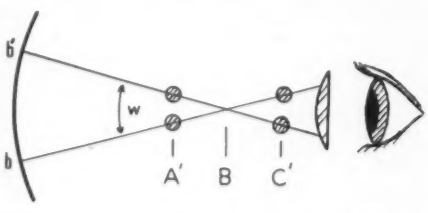

Fig. 28. The eclipse test — the circular images are schematic.

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by sliding the pedestal toward the mirror, so that the lens is focused on a plane inside the zonal focus, and again cutting in the knife-edge. Further correction of the knife-edge plane should be made if necessary, when the eyepiece should be returned to its first position for another check.

Interpreting the probable knife-edge position relative to **B**, Fig. 28, may at first be confusing. Suppose, in the diagram, the lens is focused on plane **C'**. If the knife-edge is then tried in any other outside-of-focus plane, cut-off of the left-hand image will occur first. This condition is reversed if the knife-edge is inside of focus. Now let the lens be moved toward the mirror so as to focus on plane **A'**, inside the zonal focus. If the left-hand image is the first obscured, then we know that the knife-edge is somewhere on the same side of focus. If cut-off occurs first in the right-hand image, the knife-edge is outside of focus. Any doubt as to the origin of either image can be erased by extending one's arm well out in front, so that the hand is between the slit and the mirror, and swinging it horizontally across the line of vision, thus obstructing reflection from one of the zonal apertures. Regardless of the eyepiece position, simultaneous eclipse can occur only when the knife-edge cuts the image in plane **B**.

Accuracy in locating this plane depends on the size of the angle **w**, Fig. 28, which for a zone having a radius about 96 per cent of that of an f/4 mirror, is about 6°.8. The precision of setting for this zone is probably superior to the result obtained by the bracketing method. As the radius of the zone decreases, the delicacy of this eclipse test slowly diminishes, probably reaching a practical limit for a radius about one third that of the f/4 mirror (angular diameter about 2°.3). Since the angular diameter varies inversely with the focal ratio, a corresponding increase in the usefulness of this test on mirrors of lesser focal ratio can be expected.

In Table III are given the comparative computed and measured correction differences between the 2⅞" zone and a number of other zones of a 6-inch f/4 ellipsoidal mirror. The mirror was made by Bob Frey, of the AAA's Optical Division at the Hayden Planetarium, for use in a Dall-Kirkham telescope, and was to be corrected to 73.13 per cent of the paraboloid. The measured differences in the third and fourth columns were obtained by means of the bracket and eclipse tests, respectively. The center of curvature of the center zone could not, of course, be located by the bracketing method. In attempting the eclipse test on the mirror's ¾" zone, it was found that the error in setting the knife-edge might amount to nearly 0.005", and so the effort was abandoned. The possible error for the 1" zone setting was believed not to exceed 0.002", and for the 2⅞" zone, about 0.001". One's first experiments may not, of course, be so precise. The Foucault method was used to measure 0.126" for the center zone, the center of curvature of which was located after removing the pedestal and lens and applying the eye directly to the knife-edge for observance of the shadows. Two different masks, one containing a 1-inch

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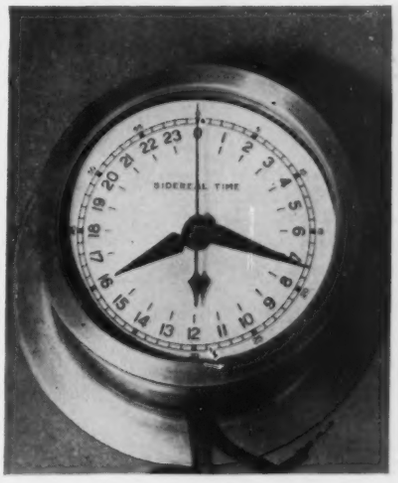

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For information on mountings and observatory equipment, see last month's issue.

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Planetarium Notes

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SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m.

STAFF: *Director,* Wagner Schlesinger. *Other lecturers:* Harry S. Everett, Albert B. Shatzel.

BUHL PLANETARIUM

Federal and West Ohio Sts., Pittsburgh 12, Pa. Fairfax 4300

SCHEDULE: Mondays through Saturdays, 3 and 8:30 p.m.; Sundays and holidays, 3, 4, and 8:30 p.m.

STAFF: *Director,* Arthur L. Draper. *Other lecturers:* Nicholas E. Wagman, J. Frederick Kunze.

November: STARS OVER PITTSBURGH. Easy methods for identifying the principal stars of winter. POETRY IN THE STARS. A special sky show celebrating English Week in western Pennsylvania.

December: STAR OF BETHLEHEM.

FELS PLANETARIUM

20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600

SCHEDULE: 3 and 8:30 p.m. daily except Mondays; also 2 p.m. on Saturdays, Sundays, and holidays. 11 a.m. Saturdays, Children's Hour (adults admitted).

STAFF: *Director,* Roy K. Marshall. *Other lecturers:* I. M. Levitt, William L. Fisher, Armand N. Spitz, Robert W. Neathery.

November: TO THE ENDS OF THE UNIVERSE. The composition, construction, and behavior of the universe as revealed by modern observation and theory will be related.

December: STAR OF BETHLEHEM.

GRIFFITH PLANETARIUM

P. O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191

SCHEDULE: Wednesday and Thursday at 8:30 p.m. Friday, Saturday, and Sunday at 3 and 8:30 p.m. Extra show on Sunday at 4:15 p.m.

STAFF: *Director,* Dinsmore Alter. *Other lecturers:* C. H. Cleminshaw, George W. Bunton.

November: COMETS AND METEORS. A great comet will develop gradually in the planetarium sky through several months of time. There will be a fine shower of meteors.

December: THE CHRISTMAS STAR.

HAYDEN PLANETARIUM

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SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.

STAFF: *Honorary Curator,* Clyde Fisher. *Chairman and Curator,* Gordon A. Atwater. *Other lecturers:* Robert R. Coles, Catharine E. Barry, Shirley I. Gale, Kenneth J. Heuer, William R. McDonald, Eugene L. Benedict, Frank H. Schleifer, Clarence V. Lee.

November: A FLIGHT TO THE ANTARCTIC. This demonstration will reveal the changing sky panorama as one travels south through the tropics to Admiral Byrd's Little America.

December: THE STAR OF BETHLEHEM.

and the other a 1½-inch central aperture, and also no mask at all, were used in this attempt. It was found that the setting was most easily and accurately made with the 1½-inch aperture. Some evidence of the reliability of the bracket and eclipse methods is given by the close agreement in the third and fourth columns of Table III.

TABLE III

CORRECTION DIFFERENCES FOR 6-INCH F/4 ELLIPSOIDAL MIRROR[1]

Zone	*Computed differences*	*Measured differences* Bracket test	Eclipse test
2⅞	zero	zero	zero
2¾	0.011	0.009	0.009
2½	0.031	0.032	0.034
2¼	0.049	0.053	0.055
2.121[2]	0.057	0.059	0.059
2	0.065	0.067	0.068
1¾	0.079	0.079	0.081
1½	0.092	0.094	0.092
1¼	0.102	0.100	0.100
1	0.111	0.110	0.108
¾	0.117	0.114	——
center	0.126	——	0.126[3]

[1]All dimensions are in inches.
[2]Equals 70.7 per cent of mirror's radius.
[3]Foucault method used for this setting.

The Wire Test. There remains an interesting supplementary test, a sort of by-product of these investigations, which can be used in looking for turned edge, or, if the mirror has not been perforated, to measure correction between the outer and center zones. (This experiment fails or lacks precision on intermediate zones.) First, procure a square inch of thin sheet metal, in one side of which is cut a wide slot. Across this slot stretch a fine wire and solder it in place. I used instead a human hair — thickness 0.0025″ — and while holding it taut across the slot secured it with two drops of molten beeswax. This accessory is mounted on the testing device, replacing the eyepiece or knife-edge, and so aligned that the wire stands vertical in two planes. In this position it can be used exactly like the Ronchi grating for detecting turned edge.

To measure correction, mask **a** (Fig. 25) is placed before the mirror, and the pedestal and lens are placed back of the wire. The pedestal is adjusted so that the outside-of-focus diffraction images of the slit can be seen, their separation being arbitrary. The purpose is to bisect with the wire the apparently single image at **B**, in which event the wire's sharply defined shadow will be seen exactly centered in each of the images. (Excessive glare can be subdued with the use of a filter.) With care the setting for the outer zone of an f/4 mirror can be made to about a thousandth of an inch. The pedestal and lens are then removed, and the testing mask is replaced with another containing a central aperture about one sixth the diameter of the mirror. The carriage bearing the wire is then advanced toward the mirror until the wire has been placed exactly at the center of curvature of the center zone. This can be accomplished with a high degree of precision by observing the shadow appearances as the wire is repeatedly passed to and fro laterally in front of the eye. Correction differences so measured should not be in error by more than 0.003″.

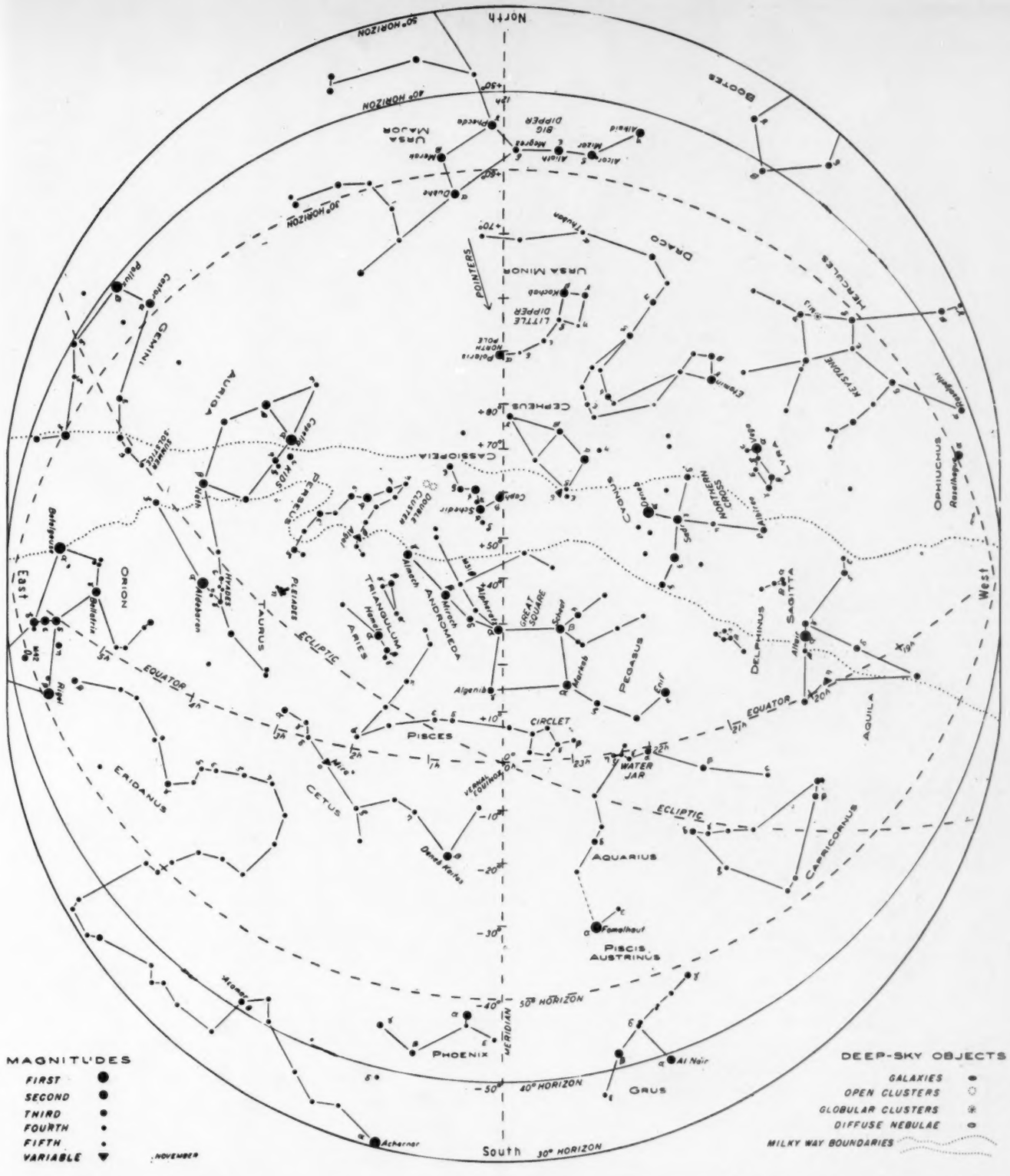
There is an apparent conflict here in the size of the diaphragm used when testing the center zone radius with a wire and with a knife-edge. Experiments show that a smaller opening is best when using the wire, whereas with the knife-edge the diaphragm should be at least one fourth the diameter of the mirror. And unless the mirror maker is experienced in the Foucault test, the wire test will lead to a more accurate setting.

Testing Apparatus. Measurements of the order of accuracy required for testing short-focus mirrors are easily possible with a screw-propelled carriage which governs the longitudinal motion of the eyepiece or knife-edge. A continuous travel of ¾″ will be ample for testing a mirror of any proportions up to a 12½-inch f/3. Slack in the screw should be taken up by tension or compression springs, constantly engaged. The carriage must be truly guided, without wobble. The propelling screw should be fitted with a calibrated dial or drum, or other device so that reading or interpolation can be made to the thousandth part of an inch. A lateral or right-angle motion for the knife-edge must be provided on top of this carriage. It must be smooth and positive, and permit no wobble. Screw propulsion is not essential, but will be the most satisfactory method of control. Means of measurement in this transverse direction are unnecessary, but may have useful experimental applications. The eyepiece can be quickly and securely mounted on the carriage by bedding it in a wad of plasticine. The knife-edge (a razor blade is best) can be similarly mounted, thus permitting easy adjustment in a vertical plane, with its edge parallel to the slit.

Because a series of zonal measurements will consume some minutes, perhaps a half hour if many zones are tested, it is imperative that the room temperature be rigidly controlled, or thermal changes within the substance of the mirror may give rise to changes in focal length that will adversely affect results. At least a half hour should elapse between the time of setting up the mirror and commencement of the tests. Needless to say, the testing stand should be heavy and solid.

There is one aspect to the bracket test that will not meet with favor from the curious, and that is that they cannot be shown what is going on. It is seldom that different eyes have identical vision, and the plane of observation is critically set in this type of testing. Thus, it is a practical certainty that another individual will find that for his eye the eyepiece is focused either in front or in back of the plane in which the operator is working. Hence no comment on the latter's judgment can be made. This drawback, if such it be, is not found in the eclipse test, which is less arduous and more interesting to perform. Also, correction differences can be taken directly from the instrument without the need of the additions and subtractions that go with the first method, and observation of the apparent shape of the mirror is possible at any knife-edge setting. The eclipse test is perhaps the more practical of the two methods.

THE END



DEEP-SKY WONDERS

THE FRONT COVER of **Sky and Telescope** for May, 1946, pictures **NGC 253**, 1^s, $0^h\ 45^m.1$, $-25°\ 34'$, a spiral of magnitude 7, size 22′ by 6′. This object is a well-known discovery of Caroline Herschel's, listed by Admiral Smyth in Cetus in his **Celestial Cycle,** but now assigned forever within the boundaries of Sculptor. Despite its brightness the writer finds few amateurs familiar with this easily located giant galaxy. A 6-inch reflector with a suitable drive will make very presentable plates of NGC 253 with only an hour's exposure.

In Cetus is **NGC 584**, 100^1, $1^h\ 28^m.8$, $-7°\ 7'$, magnitude 11.6, size 2′ by 1′.2. Smyth refers to it as "a tolerably bright round nebula of a pearly tint." It is not too easy a spiral to find, and we admire the astral admiral's care in observation — his instrument was a refractor of less than six inches aperture and probably only fair optical quality. Unfortunately, his account of this object drifts off into descriptions or nearby double and colored stars, and we wish he had commented more on the spiral. But in his day double stars were the chief objects of amateur attention — perhaps nebulae were recorded only from a sense of duty and completeness.

WALTER SCOTT HOUSTON

STARS FOR NOVEMBER

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m. local time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. For the year 1948, these simplified charts replace our usual white-on-black maps, which may be consulted in issues of prior years when information on deep-sky wonders and less conspicuous constellations is desired. Our regular charts for observers in the Southern Hemisphere appear in alternate issues.

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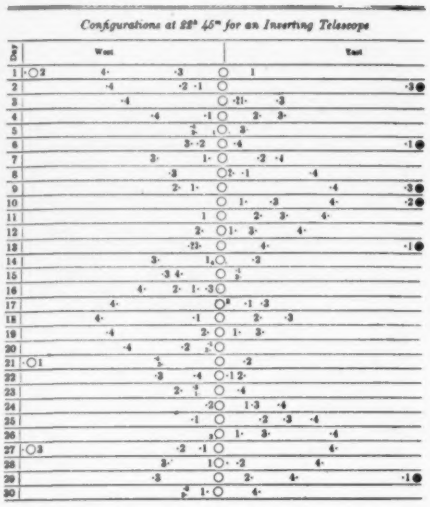
OBSERVER'S PAGE

Universal time is used unless otherwise noted.

JUPITER'S SATELLITES

This month presents the last opportunity to observe the configurations of Jupiter's four bright satellites in the evening sky for some time. The positions below are for 22:45 Universal time, which corresponds to 5:45 p.m. Eastern standard time. By noting the cycle each moon follows as it appears to revolve around Jupiter, positions of the satellites for other times may be interpolated. The evenings of November 16th and 20th present especially good opportunities to observe the moons all on one side of the planet. On the 26th, the transit egress of **II** takes place at 22:41, and its shadow comes off the planet's surface an hour and 12 minutes later. Times of all the phenomena of Jupiter's satellites for November, 1948, may be found on page 450 of the **American Ephemeris and Nautical Almanac.**

Jupiter's four bright moons have the positions shown below for the UT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the American Ephemeris and Nautical Almanac.



MINIMA OF ALGOL

November 3, 11:15; 6, 8:04; 9, 4:53; 12, 1:41; 14, 22:30; 17, 19:19; 20, 16:08; 23, 12:57; 26, 9:46; 29, 6:35. December 2, 3:24; 5, 0:13; 7, 21:02.

These predictions are geocentric (corrected for the equation of light), based on observations made in 1947. See **Sky and Telescope,** Vol. VII, page 260, August, 1948, for further explanation.

UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.

OCCULTATION PREDICTIONS

November 7-8 **86 B Capricorni m** 6.2, 20:50.0 −23-58.8, 7, Im: **A** 2:31.7 ... ... 148; **D** 2:06.9 −1.9 −2.3 112; **E** 1:49.8 −2.2 −1.3 98; **F** 1:45.0 −3.6 −1.8 111; **G** 1:09.6 −1.4 +0.5 49; **H** 0:46.2 −2.2 +1.1 62.

8-9 **143 B Capricorni** 6.2, 21:40.3 −19-51.5, 8, Im: **D** 2:55.2 −0.9 −0.7 69; **E** 2:44.4 −1.2 0.0 59; **F** 2:32.8 −2.0 +0.1 69; **H** 2:06.9 −0.8 +2.4 12.

9-10 **56 Aquarii** 6.4, 22:27.5 −14-15.1, 9, Im: **D** 4:19.6 +0.7 +2.6 358; **E** 4:19.8 ... ... 345; **F** 3:54.9 −0.1 +2.3 10.

10-11 **Psi² Aquarii** 4.6, 23:15.2 −9-28.0, 10, Im: **F** 6:10.5 −1.6 −1.6 96; **G** 6:03.8 +0.3 +2.1 0; **H** 5:40.4 −1.0 +1.1 36. Em: **F** 7:02.2 +0.2 +2.0 192; **H** 6:56.9 −1.2 −0.2 245.

13-14 **263 B Piscium** 6.4, 1:25.6 +7-41.6, 13, Im: **A** 7:21.8 −0.5 +0.9 29; **B** 7:24.7 −0.5 +1.7 15; **C** 7:16.3 −0.7 +0.5 42; **D** 7:19.2 −0.6 +1.4 22; **E** 7:05.9 −0.9 +1.3 29; **F** 6:47.6 −1.7 +0.7 57; **H** 6:36.6 +0.4 +4.3 352.

18-19 **136 Tauri** 4.5, 5:50.0 +27-36.1, 18, Em: **A** 7:54.3 ... ... 328; **C** 7:58.2 −2.0 −2.5 307; **D** 7:34.1 ... ... 338; **E** 7:23.8 −2.7 −3.1 318; **F** 7:18.0 −2.5 −0.1 280.

20-21 **Omega Cancri** 5.9, 7:57.8 +25-32.2, 20, Em: **A** 10:10.2 −1.9 −0.3 263; **B** 10:06.7 −1.7 −0.6 271; **C** 9:58.8 −2.7 +1.2 242; **D** 9:56.2 −2.1 +0.2 258; **E** 9:23.9 −2.5 +3.2 229; **G** 9:03.6 −1.2 +1.0 273; **H** 8:25.5 −0.3 +4.1 218; **I** 8:52.3 −1.0 +1.2 273.

December 8-9 **351 B Aquarii** 6.5, 23:32.9 −7-45.1, 8, Im: **A** 23:00.0 ... ... 137; **B** 22:44.9 ... ... 112; **C** 22:38.3 ... ... 124; **D** 22:27.1 −2.8 +0.4 101; **E** 21:56.9 −1.9 +1.3 87.

For selected occultations visible at standard stations in the United States and Canada under fairly favorable conditions, these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, a and b quantities in minutes, position angle; the same data for each standard station westward.

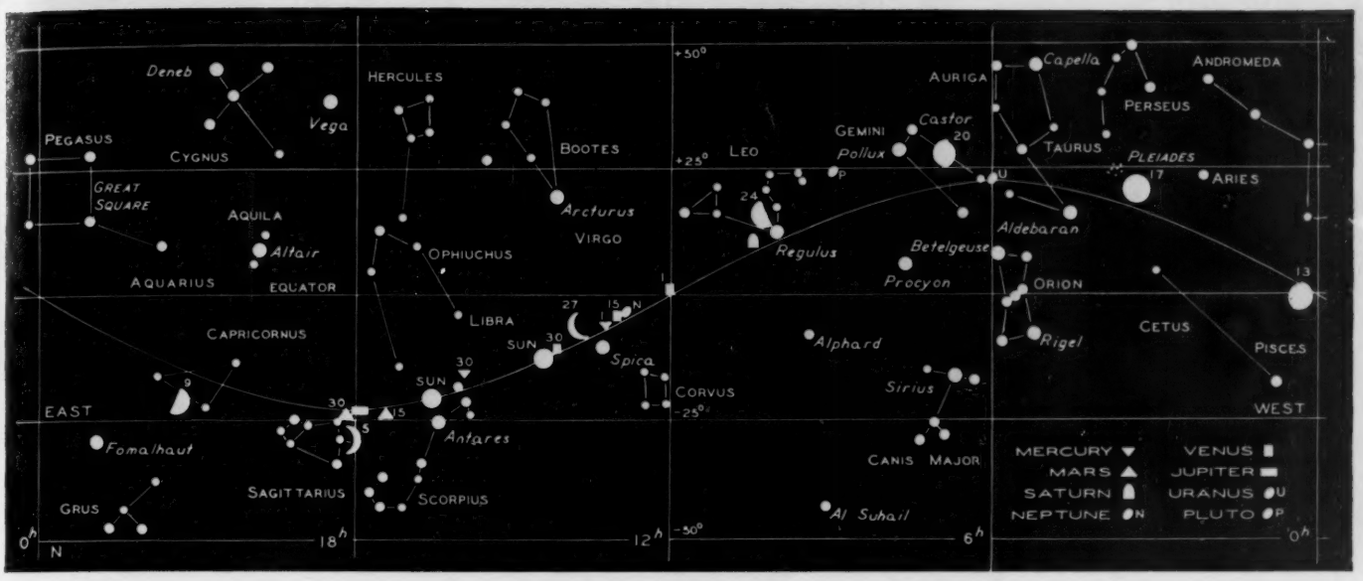
Longitudes and latitudes of standard stations are:

A	+72°.5, +42°.5	**E**	+91°.0, +40°.0
B	+73°.6, +45°.6	**F**	+98°.0, +30°.0
C	+77°.1, +38°.9	**G**	+114°.0, +50°.9
D	+79°.4, +43°.7	**H**	+120°.0, +36°.0
		I	+123°.1, +49°.5

The a and b quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. Lo, lat. L) within 200 or 300 miles of a standard station (long. LoS, lat. LS). Multiply a by the difference in longitude (Lo — LoS), and multiply b by the difference in latitude (L — LS), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your own standard time.

NOVEMBER METEORS

The Leonid meteor shower maximum comes at about the same time as full moon, the 16th. Therefore, few meteors will be seen, and the shower will probably not be worth observing. E. O.



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Sun: The only total solar eclipse this year takes place on November 1st. The path of totality crosses the Indian Ocean from Africa north of Madagascar almost to New Zealand. The maximum duration of totality is nearly two minutes. Partial phases can be seen from South Africa and Australia.

Mercury reaches greatest elongation west on November 4th, the most favorable elongation this year. Although the planet is only 19° from the sun, it will rise 1½ hours before sunrise. The maximum brightness is about −0.4, and Mercury can be observed for two weeks more.

Venus remains the bright morning star rising in the pre-dawn sky. Its stellar magnitude is −3.5. Venus traverses Virgo during the month, passing 4° north of Spica on the 19th.

Mars is too near the sun to be seen.

Jupiter may be seen for a short time each evening low in the southwest sky. Its setting time is two hours after the sun in mid-November.

Saturn reaches western quadrature on November 28th, hence rises about midnight. Its magnitude is only +0.9, due to the small inclination of its rings. They are tilted 7° and slowly closing.

Uranus rises shortly after sunset. It is retrograding, very close to the summer solstice, northwest of 1 Geminorum.

Neptune remains invisible due to its proximity to the sun. E. O.

PHASES OF THE MOON

New moon	November 1,	6:02
First quarter	November 8,	16:46
Full moon	November 16,	18:31
Last quarter	November 23,	21:22
New moon	November 30,	18:44

VARIABLE STAR MAXIMA

November 3, R Normae, 7.2, 152849; 7, W Andromedae, 7.5, 021143a; 10, SS Virginis, 6.9, 122001; 18, R Sagittarii, 7.2, 191019; 18, R Cassiopeiae, 6.5, 235350; 24, T Columbae, 7.6, 051533; 24, S Canis Minoris, 7.5, 072708.

These predictions of variable star maxima are made by Leon Campbell, recorder of the AAVSO, Harvard College Observatory, Cambridge 38, Mass. Serious-minded observers interested in making regular telescopic observations of variable stars may write to Mr. Campbell for further information.

Only stars are included here whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

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A striking new wall chart by Josef Klepesta shows the stars brighter than magnitude 5.0 in six different colors according to their spectral classes. Centered on the north pole, the map extends to 45° south declination, and is 25½ inches in diameter. The geometrical constellation patterns are shown in fine solid lines, and constellation boundaries are indicated by dotted lines. The star name or number, Greek letter, and visual magnitude to hundredths are given for each star. Mappa Coelestis Nova is decorative, and provides in an unusual form a mine of information for the stargazer.

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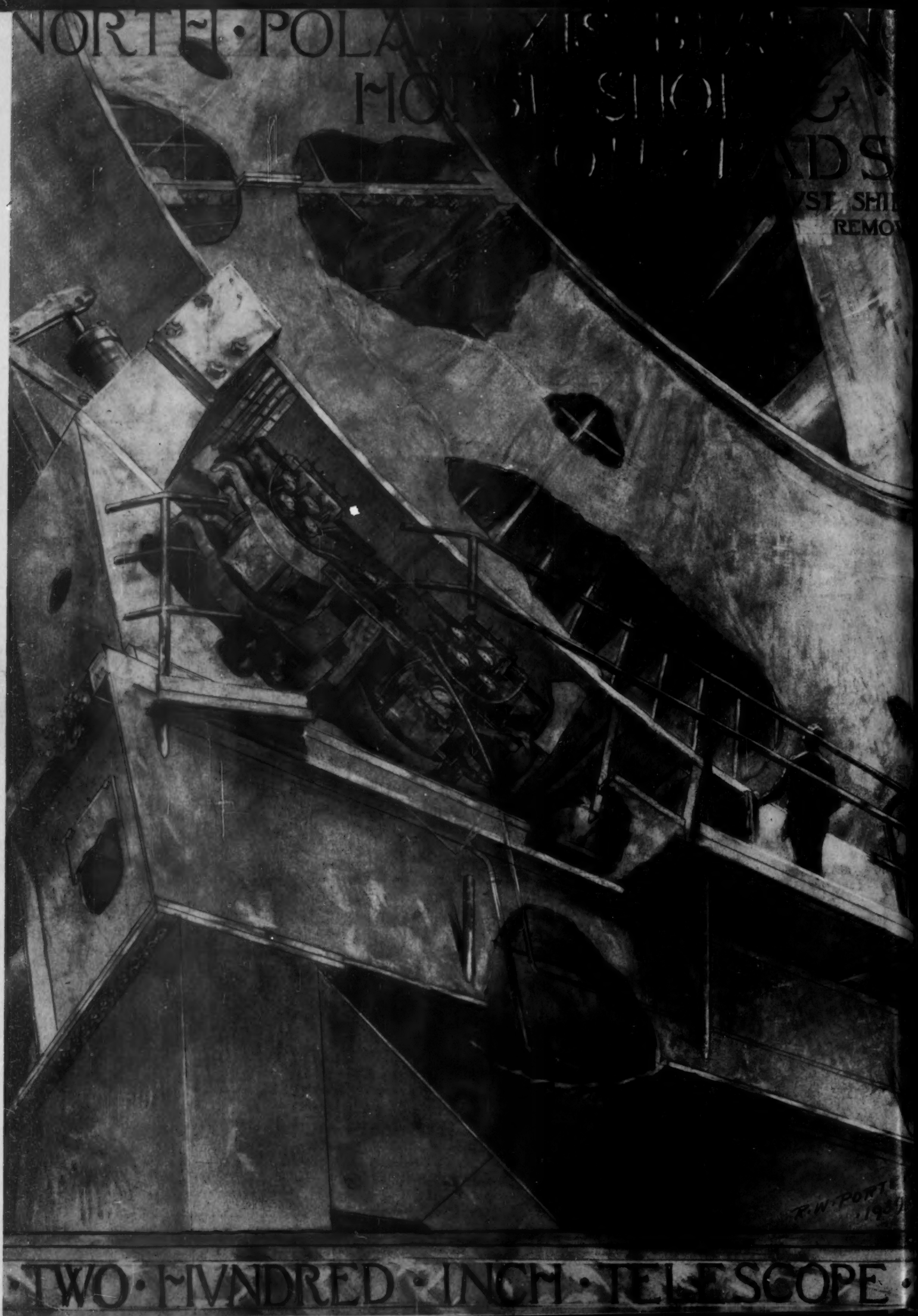
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